TECHNICAL SUPPLEMENT DOCUMDENT
FOR
PREVENTION OF SIGNIFICANT DETERIORATION
PERMIT NO. PSD-03-03
CARDINAL FG COMPANY
WINLOCK, WASHINGTON

1.0 INTRODUCTION

1.1 THE PSD PROCESS

The Prevention of Significant Deterioration (PSD) procedure is established in Title 40, Code of Federal Regulations (CFR), Part 52.21 and in Washington State regulations, WAC 173-400-141. Federal rules require PSD review for all proposed construction of new air pollution sources or modification of existing air pollution sources that meet certain overall size, and pollution rate criteria. The objective of the PSD program is to prevent serious adverse environmental impact from emissions into the atmosphere by a proposed new or modified source. PSD rules require that an applicant use the most effective air pollution control equipment and procedures after considering environmental, economic, and energy factors. The program sets up a mechanism for evaluating and controlling air emissions from a proposed source to minimize the impacts on air quality, visibility, soils, and vegetation.

The Environmental Protection Agency delegated the authority to implement the PSD program described in title 40 C.F.R. 52.21 and its supporting guidance and procedures documents to the Engineering and Technical Services staff[1] of the Air Quality Program of the Washington State Department of Ecology.

1.2 THE PROJECT

1.2.1 Location

Cardinal FG Company (Cardinal) proposes to build a 650 ton per day flat glass plant near Winlock, Washington (Lewis County). The proposed facility will use "float" technology wherein the flat glass is formed on the surface of liquid zinc in a natural gas-fired furnace. The proposed glass plant will be located in the proposed Napavine Industrial Park near the intersection of Avery Road and Highway 603. The site is approximately 30 miles (48 kilometers, km) south of Olympia and 5 miles (8 km) south of Chehalis. The project site relative to Chehalis, Napavine, Winlock, and Evaline is shown on the map, below, at approximately N 46^{o} 32' 20", E 122^{o} 56' 10" (UTM coordinates: 504804E 5153907N). The site of the proposed project is within a Class II area that is in attainment or unclassified with regard to all pollutants regulated by the National Ambient Air Quality Standards (NAAQS) and state air quality standards. The site of the proposed project is within 100 km of the Oregon-Washington border and seven tribal nations: Chehalis, Muckleshoot, Nisqually, Puyallup, Shoalwater, Skokomish, and Squaxin Island.

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[1] Units in the Technical, Information, and Engineering Services Section

1.2.2 Flat Glass Making Process

There are at least eight distinct product sectors based on glass: Container (bottles), flat (e.g., window), continuous filament (ambient thermal insulation), mineral wool (sound and fire protection insulation), ceramic fibre (high temperature insulation), domestic (drinking glasses), frit (ceramic glazes), and special (electronics, cookware). The basic ingredients of glass are silica sand and soda ash (sodium carbonate, Na_2CO_3). Glass is made by melting these basic materials, and forming them into the desired product geometry. Beyond that, the sectors vary widely in raw material additives, processing equipment and conditions, and product quality requirements. The applicability of a given pollutant emission control technology can depend greatly on these differences between the glass sectors. Consequently, pollutant emissions control technologies demonstrated as acceptable for one sector cannot be assumed to be applicable to all sectors.

Flat glass is made from the following raw materials: Silica sand, soda ash, nepheline syenite feldspar, high calcium limestone (calcium carbonate,$CaCO_3$), dolomitic limestone (calcium-magnesium carbonate, $CaCO_3 \cdot MgCO_3$), salt cake (sodium sulfate, Na_2SO_4), cullet (broken glass), rouge (iron), and carbon. Other additives may be incorporated to give desired special product qualities (e.g., color or photo-filtration). The proposed Cardinal facility will feed the mixed raw materials into a 200 million British thermal unit per hour (MBtu/hr) natural gas-fired furnace. The furnace is a side port, regenerative system. Raw materials and cullet enter the melting section, where they are refined and temperature conditioned.

In the long history of the technology of making flat glass, the process has evolved from a manual adaptation of glass blowing through pouring the molten glass onto a hot plate (hence the name "plate glass") to the current "float" technology predominant in the world today. Cardinal will manufacture glass using float technology.

In the float glass manufacturing process, the molten glass is poured onto the surface of a tin bath and a floating glass ribbon extends the length of the bath to the exit. The formation and stabilization of the continuous sheet of glass takes place within the furnace itself. The float or "tin" bath consists of a refractory lined bottom containing molten tin 2 to 4 inches deep and a steel roof housing electric heating elements. Tools are inserted through seals in the sides of the bath to control ribbon width, thickness, and temperature. Rolls at the bath exit pull the floating ribbon through the bath. A hydrogen and nitrogen atmosphere is maintained inside the bath to prevent tin oxidation.

The glass ribbon exits the tin bath and enters the lehr. The lehr is a roller hearth oven designed to slowly cool the glass ribbon after it exits the float bath. Since the lehr must anneal the glass to prevent the formation of excessive stresses in the finished product, cooling rates are controlled both across the width of the lehr and along its length. In the first part of the lehr, heat is supplied by electric heating elements to compensate for heat losses from the ribbon edges. A system of fans and ducts provides atmospheric air as the cooling medium. Heat is transferred from the glass to the air by a combination of tube heat exchangers and by direct impingement of air on the glass. The glass ribbon is transported through the lehr by driven rolls. Sulfur dioxide (SO2) from storage tanks is injected on to the rollers and the top and bottom surfaces of the glass to prevent staining. After exiting the lehr, the solidified glass sheet passes through inspection, cutting/trimming, snapping to size, and packing.

1.2.3 Cardinal's Air Pollutant Emissions Sources

- Melting furnace
- Cullet (waste glass) return system
- Raw materials receiving, transport, and mixing
- Annealing lehr
- Glass cutting
- Emergency generator

1.3 PSD APPLICABILITY

Cardinal will be a “major source”, as defined in PSD regulations (40 CFR 52.21) because it will emit more than 250 tons per year (TPY) of a regulated pollutant (1,187 TPY carbon monoxide and 883 TPY nitrogen oxides). Therefore, emission increases of each regulated pollutant from the facility resulting from new construction must be compared to the corresponding PSD significant emission rate (SER) threshold in order to determine if PSD review is required. Any criteria pollutant expected to have an emissions increase in excess of its SER threshold is subject to PSD permitting.

Cardinal submitted the Prevention of Significant Deterioration (PSD) Permit Application for the proposed glass making facility on October 27, 2003. On November 17, 2003, Ecology notified Cardinal that the original application was found to be incomplete, and gave Cardinal a description of the insufficiencies. On January 12, 2004, Ecology received supplementary information from Cardinal intended to satisfy the insufficiencies of the permit application. On February 12, 2004, Ecology notified Cardinal that the original application in conjunction with the supplementary material constituted a complete application. The emissions increases associated with this project as proposed by Cardinal and corresponding SER thresholds are shown in Table 1, below:

Table 1: Emissions Increases from Cardinal Glass Plant - Winlock

Pollutant	Emissions Increase TPY	PSD SER TPY
Nitrogen oxides, NO_X	883	40
Carbon Monoxide, CO	772	100
Sulfur dioxide, SO_2	72	40
Volatile Organic Compounds, VOCs	56	40
All particulate matter (PM) is assumed to be less than 10 microns in diameter (PM_{10})	121	15
Sulfuric acid mist (H_2SO_4)	6.9	7
Fluorides (F^-)	2.9	3
Lead (Pb)	0.03	0.6

As shown in Table 1, the Cardinal project is subject to new source review (NSR) under PSD rules for NO_X, CO, SO_2, VOCs, and PM_{10} emissions[2] because net emissions increases are greater than the respective significant emissions rates. Control of H_2SO_4, F^-, and Pb will be included in the notice of construction approval to be issued separately under the jurisdiction and authority of the Southwest Clean Air Authority (SWCAA). If this permit is approved by Ecology, its conditions will be enforced by SWCAA in conjunction with other application regulations.

1.4 NEW SOURCE PERFORMANCE STANDARDS

The United States Environmental Protection Agency (EPA) has established performance standards for a number of air pollution sources in 40 CFR Part 60. These "New Source

[2] Because expected PM emissions are in excess of 25 TPY, technically, the proposed project is subject to PSD review for PM larger than 10 microns in diameter. However, since all PM emissions are assumed to be PM_{10}, all issues under PSD review that deal with PM_{10} will cover PM as well.

Performance Standards" (NSPS) represent a minimum level of control that is required on a new source. Air emissions filterable particulate material from flat glass manufacturing are regulated by the New Source Performance Standards under 40 CFR Part 60.291 - Standards of Performance for Glass Manufacturing Plants. Cardinal will be subject to the requirements under Section 60.292. This limits filterable PM emissions from the furnace to 0.45 lbs/ton of glass produced as measured by the front half of the USEPA Method 5 test. The filterable PM/PM_{10} emission limit proposed for the melting furnace of this project is 0.09 lbs/ton. This is more restrictive than the limit required under 40 CFR Part 60.292. There are no NSPS requirements for other pollutant emissions or processes in glass making.

1.5 STATE REGULATIONS

Cardinal is subject to Notice of Construction requirements under Ecology regulations, Chapters 173-400 and 173-460 WAC.

2.0 DETERMINATION OF BEST AVAILABLE CONTROL TECHNOLOGY

2.1 DEFINITION and POLICY CONCERNING BACT

All new sources are required to use Best Available Control Technology (BACT). BACT is defined as an emissions limitation based on the maximum degree of reduction for each pollutant subject to regulation, emitted from any proposed major stationary source or major modification, on a case-by-case basis, taking into account cost effectiveness, economic, energy, environmental and other impacts (40 CFR 52.21(b)(12)).

The "top down" BACT process starts by considering the most stringent form of emissions reduction technology possible, then analyzing all reasonably available information to determine whether the related control method is technically feasible and economically justifiable[3]. If proven technically infeasible or economically unjustifiable, then the next most stringent level of reduction is considered in the same manner. The most stringent emission reduction (lowest emission level) that can be achieved by at least one control technology that is technically feasible and economically justifiable is determined to be BACT. The emission level and its related control technology are usually interchangeably referred to as the "BACT" of the permit decision. However, only the emission level is mandated in the permit. The source is generally free to apply any control technology with the requirement that it demonstrate BACT-level performance capability.

2.1.1 Technical Feasibility

PSD applicants often propose that a given emission control technology is infeasible for their facility unless it has been previously used in exactly the situation under consideration. This is insufficient evidence to conclude that the control technology is technically infeasible. EPA's new source review guidance[4] suggests, "The control alternatives should include not only existing controls for the source category in question,

[3] Other factors are also subject to consideration, e.g., energy consumption (regardless of short-term unit cost of the energy source) and local/regional community values. However, these are rarely considered in such a manner that would trump technical feasibility and economic justifiability.

[4] USEPA New Source Review Workshop Manual, Chapter B §IIIA (October, 1990)

but also (through technology transfer) controls applied to similar source categories and gas streams." EPA guidance also indicates that in order for such a "technology transfer" to be judged technically feasible, its application should be relatively seamless and free of technical speculation[5]. In the BACT determination for this permit, technical feasibility was judged subject to the following criteria:

- The control technology was previously applied to emission streams sufficiently similar to the one being proposed[6]. Any differences between the previous applications should not impact the control technology performance. The control technology and emission limit should not cause deterioration of the related process equipment, or irretrievably affect product quality.
- The emission limit associated with the BACT determination, including consideration for normal and reasonable control variability, was shown to be consistently achievable under normal and conscientious operating practices[7].
- It is not in the interests of the source, the regulatory agency, or the general public to set emission limits that will result in frequent violations even though the control technology was well-designed and installed and conscientiously operated by the source. Such situations increase costs to the source and regulatory agency (and consequently the public) for investigation, litigation, and reconstruction without benefit to the environment.

2.1.2 Economic Justifiability

"Economic justifiability" does not mean "affordable by the source."[8] Nor does it mean the most any other source in the world has spent on air pollutant emissions control. In the BACT determination for this permit, economic justifiability was judged subject to the following criteria[9]:

- In order to eliminate a BACT candidate on the basis of cost effectiveness, the cost must generally be disproportionately high for the applicant when compared to the cost of control for the pollutant in recent BACT determinations in the applicant's source category.
- A BACT candidate may also be eligible for elimination if it has been applied as BACT in only a very limited number of cases and there is a clear demarcation

[5] Court Decision on Steel Dynamics, Inc., PSD Appeals 99-04 and 99-05 before the USEPA Appeals Board (June 22, 2000)

[6] USEPA NSR Workshop Manual (1990), §IV.A.: "Add-on controls … should be considered based on the physical and chemical characteristics of the pollutant-bearing stream. Thus, candidate add-on controls (are those that) may have been applied to … emission unit types that are similar, insofar as emissions characteristics, to the emissions unit undergoing BACT review."

[7] USEPA NSR Workshop Manual (1990), §IV.A.1: "Technologies which have not yet been applied to (or permitted for) full scale operations need not be considered available …" and USEPA NSR Workshop Manual (1990), §IV.C.2.: "… the applicant should use the most recent regulatory decisions and performance data for identifying the emissions performance level(s) to be evaluated …"

[8] USEPA NSR Workshop Manual (1990), §IV.D.2: "… applicants generally should not propose elimination of control alternatives on the basis of … affordability …"

[9] USEPA NSR Workshop Manual (1990), §IV.D.2.c

between the cost of that technology and control costs accepted as BACT in recent determinations in the applicant's source category.

Where economic justifiability bases are needed for purposes of comparison, "the applicant's source category" is restricted in this permit decision to flat glass, manufacturers and to a limited extent other glass sectors in the United States. EPA guidance directs that the search for potentially technically feasible pollutant emission control technologies should be worldwide. However, the applicant's source category is not necessarily international.

Regulatory agency positions on economic justifiability thresholds vary widely from country-to-country. Flat glass markets are likely to be regional, but certainly are not trans-oceanic. Consequently, competitive considerations between the United States and, for example, Europe are not comparable. Economic justifiability determinations are also frequently based on local/regional environmental versus economic objectives. Within the United States, a BACT determination judged justifiable in a nonattainment area would often not be judged justifiable in an attainment area. In the United States, nonattainment correlates with population density. The highest concentration of nonattainment areas is in the highly populated Northeastern states and Central/Southern California coasts. In particular, California is generally recognized as having the most stringent BACT determinations. Inherent in such determinations is often a tolerance for less well-demonstrated technologies. Similarly, the European regions having the most stringent emission control in the glass industry are highly populated (about 2.5 times California's population density and 7 times Washington's). Finally, varying exchange rates, cost accounting methods, government-industry cooperation, and corporate profitably expectations make direct comparisons of pollutant emission control technology costs very difficult.

2.2 CARDINAL'S SOURCES REQUIRING BACT ANALYSIS

Table 2, below, lists Cardinal's unit operations that will have emissions of any air pollutant above the de minimis level[10] that triggers requirement of a BACT analysis. The unit operations having an emissions rate above the de minimis level for a particular air pollutant require an associated BACT analysis under this PSD permit evaluation. Any unit operations requiring control technology to achieve emission rates below the PSD BACT de minimis must have application and proper operation of that control technology included as a requirement in the companion notice of construction approval issued by SWCAA.

[10] Request for Clarification of Policy Regarding the "Net Emissions Increase," USEPA Memorandum, John Calcagni, Director Air Quality Management Division to William B. Hathaway, Director Air, Pesticides, and Toxics Division (September 18, 1989): "… it would not be sensible to subject a small increase (e.g., 2 tons per year [tpy]) to a full PSD review … The PSD reviews of such small emissions could place a significant resource burden on both applicants and review agencies and would likely result in minimal, if any, emissions reductions or air quality benefits from the application of BACT." and Response to July 23, 1981 letter from S. Goldberg and P. Raher, Hogan and Hartsen by Edward Reich, USEPA Director of the Division of Stationary Enforcement: "… a one ton/year increase would result in an emission increase which could not practically be approximated …"

Table 2: **Air Pollutant Emissions from Cardinal's Unit Operations**

Unit Operation	Air Pollutant	Annual Emissions Rate TPY
Glass furnace and lehr	NO_X	883
	CO	771
	SO_2	72
	PM/PM_{10}	111.4
	VOCs	11.9
Baghouses: Cullet, Glass sheet cutting/packing, Raw material handling	PM/PM_{10}	9.2
Glass cutting lubricant evaporation	VOCs	43.9

2.3 GLASS FURNACE

2.3.1 NO_X

There are several processes that might be applied for controlling NO_X emissions from flat glass furnaces:

Table 3: BACT Candidates for NO_X Reduction from Float Glass Furnaces

NO_X Reduction Process	NO_X Reduction Level
Dry absorption	95-98%
SCONOx™	90-95% (Combustion turbines)
Oxy-Fuel Melting	70-90%
Selective Catalytic Reduction (SCR)	70-80% (Glass furnaces)
The FENIX™ process	60-65%
Chemical Reduction by Fuel (CRF), 3R Process™	40-85%
Air Staging (including oxygen enhanced)	30-70%
Selective Non-Catalytic Reduction (SNCR)	30-70% (Glass furnaces)
Low NOx burners	30%
Flue gas recirculation	25%
Reduced air/fuel ratio	10%

2.3.1.1 Dry absorption

The only dry NO_X absorption technology of which Ecology is aware that is in the process of commercialization is the Pahlman Process[11]. The Pahlman Process uses a proprietary formulation of manganese dioxide to absorb NO_X and SO_2 in the form of manganese nitrate [$Mn(NO_3)_2$] and manganese sulfate ($MnSO_4$). The manganese nitrate is regenerated to manganese dioxide in a proprietary process. Demonstration runs using a

[11] Exclusive vendor: EnviroScrub Technologies Corporation, 1650 West 82nd Street, Suite 650, Minneapolis, MN 55431

skid-mounted pilot unit at DTE Energy's River Road Plant (June, 2003) and Minnesota Power's Boswell Energy Center (January, 2004) showed a NO_X reduction of over 95% and a SO_2 reduction of over 99%. Because the Pahlman Process also claims to be able to remove mercury from combustion gasses, it is currently primarily being developed with the intent of application to coal-fired power plants. There have been no commercial applications yet in any industrial sector. While this appears to be a very interesting and promising NO_X control technology, **Ecology concludes dry NO_X absorption is not technically feasible for the proposed Cardinal facility**.

2.3.1.2 SCONOx™

The $SCONO_X$™ NO_X control process consists of passing the exhaust combustion gasses across a solid reactant surface. $SCONO_X$™ reduces the NO_X by reacting it with potassium carbonate (K_2CO_3), and reducing the resulting potassium nitrate (KNO_3) with hydrogen to form N_2 (and regenerate the K_2CO_3). $SCONO_X$™ has been applied in practice only to small-to-medium sized electricity-generating gas turbines[12]. Successful application appears to be strongly dependent on the emission stream having low levels of particulate and sulfur oxides. EPA's Region I describes the SCONOx™ system's applicability as limited "to natural gas-fired combined cycle turbine(s) using water injection."[13] Emissions concentrations of these pollutant constituents from flat glass furnaces are relatively high. **Ecology concludes the nature of the emission stream from a flat glass furnace is insufficiently similar to the emission streams in previous $SCONO_X$™ applications for $SCONO_X$™ to be considered technically feasible for the proposed Cardinal facility**[14].

2.3.1.3 Oxy-Fuel Melting

Oxy-fuel melting involves the replacement of the combustion air with 90% pure oxygen. Use of this technique appears to be driven by its inherent energy efficiency. It has been widely adopted by the glass industry with the exception of the float glass sector. Excluding the float glass sector, about 30% of the U.S. glass furnaces use oxy-fuel firing. There have been three recent conversions (out of 43 possibilities) of float glass furnaces to oxy-fuel firing, all in the U.S.[15]

Use of oxy-fuel firing in the float glass sector appears to be inhibited by a high capital investment requirement, concerns about furnace refractory deterioration and effects on product quality. Float glass furnaces are generally larger and more expensive than the

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[12] $SCONO_X$™ is a product of Goal Line Environmental Technologies, represented by Sunlaw Energy Corporation (Los Angeles, CA). The first commercial-size SCONOx system was installed in May 1995 at the Sunlaw-U.S. Growers 30-megawatt power plant in Vernon, CA. A second SCONOx unit, with improved economic and operational design, was installed in December 1996 at Sunlaw's other 30 megawatt power plant, Federal Cold Storage (This is not currently shown as an active site on the Goal Line web page, http://www.alstomenvironmental.com/sconox/). A SCONOx unit was installed on a 5-megawatt turbine in Andover, MA in 1998.

[13] http://www.epa.gov/region1/assistance/ceit_iti/tech_cos/goalline.html

[14] USEPA New Source Review Workshop Manual (1990), §IV.A.: "Add-on controls … should be considered based on the physical and chemical characteristics of the pollutant-bearing stream. Thus, candidate add-on controls (are those that) may have been applied to … emission unit types that are similar, insofar as emissions characteristics, to the emissions unit undergoing BACT review."

[15] Pilkington (Toledo, OH) 2000, PPG (Meadville, PA and Fresno, CA) 2001, 2002

furnaces in the other sectors, and reduced furnace life is a greater economic consideration. Oxy-fuel burning leads to increased temperature and gas-phase alkali concentration in the furnace. This is the main pathway for vapor attack on the glass furnace refractory[16]. Research is on-going to counteract the generally-acknowledged problem of refractory deterioration[17, 18, 19]. The Integrated Pollution Prevention and Control report on the glass industry for the European Commission (IPPC)[20] said that the float glass furnaces having converted to oxy-fuel firing did so because of "site-specific issues" that made it more advantageous, but did not elaborate. The IPPC report also said, "The very high capital investments and high quality requirements for flat glass make the risks higher than in some other sectors."

Relative to reduction in NO_X formation, the mechanism of oxy-fuel firing is to eliminate to the extent possible any nitrogen from the combustion process. The only nitrogen entering the furnace is from unavoidable leaks in the raw material entry and product exit sections. Consequently, the potential is excellent for extremely low NO_X emission levels. However, its use is intimately tied to the furnace and burner design and product formulation that are still in research and demonstration phases. In general, it is inappropriate for the permitting agency to dictate the design of the underlying production process as part of the BACT determination unless there is virtual certainty that it will be seamlessly applicable. Ecology cannot claim to have sufficient expertise in glass furnace design or float glass product requirements to make such a determination. Consequently, **Ecology concludes that oxy-fuel firing is not technically feasible for the proposed Cardinal facility**.

2.3.1.4 SCR

SCR involves reacting NO_X with ammonia over a solid-phase catalytic bed. Excess ammonia is fed through the catalyst bed to push the NO_X reduction to the desired level. The excess ammonia leaves the system as "ammonia slip." Ammonia is a toxic air pollutant under 173-460 WAC, and contributes to visibility reduction and increased nitrogen deposition in Class I areas. However, it is not a criteria pollutant under PSD permitting.

There are three basic types of SCR technology: low temperature catalysts, which have the advantages of low pressure drop and lower-temperature operation, but are susceptible to sulfur and particulates; medium-temperature catalysts, which have historically been the workhorse of the technology; and high-temperature catalysts, which tend to be zeolites (a molecular sieve)[21].

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[16] "Complex Phase Equilibria in Refractories Design and Use," Lee, Argent, and Zhang; J. Am. Ceramic Soc., V-85, #12, 2911 (2002)
[17] "Oxy-Fuel Fired Glass Melting Technology -Experience, Evolution and Expectation **,"** Kobayashi, H. and Tasca, A; Copyright 2003 Praxair, Incorporated. All rights reserved
[18] Telephone conversation between Ronald W. Schroeder (Praxair, Inc.) and Bernard Brady (Ecology); April 21, 2004
[19] "Oxy-Fuel Economics Update Based on Case Histories," Schroeder and Zak, presented at the 56th Conference on Glass Problems, University of Illinois (October 24-25, 1995)
[20] "Integrated Pollution Prevention and Control (IPPC)," Reference Document on Best Available Techniques in the Glass Manufacturing Industry for the European Commission (December, 2001)
[21] "Controlling NO_X emissions, Part 2," Bradford, et al., Chemical Engineering Progress, 38 (April, 2002)

Low-temperature SCR can be operated at 300°F to 680°F. Generally, its use is restricted to installations firing natural gas with a clean combustion exhaust. The main disadvantage of low-temperature SCR is its susceptibility to precipitation of condensable sulfate salts and to fouling by particulates. Even if sulfates are not already present in the exhaust, the catalyst will convert varying portions of any SO_2 to sulfur trioxide (SO_3). In any SCR application, ammonium sulfate and sulfite are formed from reaction of the ammonia slip with SO_2 and SO_3. Exhaust from a typical natural gas-fired combustion unit that is to be treated by a low-temperature SCR system would have a filterable particulate ("dust") concentration of about 0.0007 grains per dry standard cubic foot (gr/dscft) and an SO_2 concentration of about 2 parts per million dry volume basis (ppmdv). The catalyst can tolerate relatively short exposure to SO_2 concentrations up to 20-25 ppmdv, typical of oil-firing. However, continued exposure of such SO_2 concentration levels degrades catalyst activity.

Medium-temperature catalysts operate in the 500°F to 725°F temperature range. They can withstand high sulfur and high particulate loadings, sometimes with the assistance of soot blowers to stir up and flush the catalyst surface. Low-vanadium catalysts can be used to minimize the conversion of SO_2 to sulfate. The main disadvantage of medium-temperature catalysts is that the proper temperature often does not exist in the flue gas train. This often requires revamp of the heat recovery train to obtain the proper temperature-location for the SCR. In addition, the honeycomb used with medium-temperature SCR catalysts has a relatively high pressure drop, and the catalyst is vulnerable to sintering from localized high concentrations of ammonia.

High-temperature catalysts operate in the 650°F to 1,100°F range. They can be used in high-sulfur applications. The reaction occurs inside the molecular sieve body, rather than on the surface. This eliminates the sulfur poisoning of metallic catalysts and reduces the conversion of SO_2 to sulfate.

Because the exhaust temperature anticipated from the Cardinal furnace is about 350 ^{o}F., a low temperature SCR system is the logical design choice. In the Cardinal application, the SCR would be exposed to sodium sulfate dust from and any SO_2 passing the dry scrubber. The expected "dust" concentration in Cardinal's exhaust stream is about 0.006 gr/dscft. This is over ten times the dust concentration to which the catalyst is typically exposed in a low-temperature SCR application. Cardinal's exhaust is expected to have an SO_2 concentration of about 30 ppmdv. As discussed above, low-temperature SCR catalysts cannot tolerate continued exposure to this high an SO_2 concentration. In addition, the particulate from the glass furnace may contain magnesium, calcium, sodium, and potassium or other heavy metal oxides that are also catalyst poisons[22, 23].

In order to apply a medium-temperature SCR design, Cardinal's exhaust would have to be at least 150 °F hotter. As noted above, in some applications it is possible to redesign the associated heat recovery train to insert the SCR in the optimal location, temperature-wise. Because the Cardinal glass furnace is a regenerative design, there is no heat recovery

[22] "Optimizing SCR Catalyst Design and Performance for Coal-Fired Boilers," Scot Pritchard, et al.; Presented at EPA/EPRI 1995 Joint Symposium Stationary Combustion NOx Control (May 16-19, 1995)
[23] "SCR Catalyst Performance on U.S. Coal Fired Boilers," Julie Crowe, Hitachi Zosen Engineering, Houston, TX (http://www.herallc.com/pdf/crowe.pdf)

train. Revamping of the heat recovery train is not an option. In theory, Cardinal's exhaust gas could be re-heated sufficiently to allow use of a medium-temperature SCR system. However, Ecology is aware of no SCR installation where extensive post-process re-heating was installed for such a purpose. Ecology considers this generally to be a poor use of irreplaceable energy resources[24] and poor engineering design. In addition, as previously noted, the medium-temperature SCR system is characterized by a relatively high pressure drop. Addition of a re-heat (and perhaps an additional heat recovery) system would further increase this pressure drop. Because the furnace is inseparable from the flat glass making process, variations in furnace back-pressure can affect product quality in unpredictable ways (e.g., cause seed-formation, pitting, and gas bubbles). The barriers to using a medium-temperature SCR design on Cardinal's glass furnace apply to an even higher degree for a high-temperature SCR design.

The Euroglas SA facility in Homburg, France is the only flat glass plant of which Ecology is aware of that uses SCR to control NO_X emissions. It is unclear from available information[25] whether the Euroglas SCR is a low- or medium-temperature design. Euroglas is apparently able to cope with dust deposition on the catalyst by blowing air through the catalyst bed several times a day. The duration of this exercise and its effect on overall emissions or product quality is not public information.

In Europe, as of 1999, most glass plants using SCR (float or other sector) have been de-commissioned due to technical problems[26]. It is generally believed that "the SO_2 removal efficiency of gas scrubbing systems currently used within the glass industry is unlikely to be adequate for SCR."[27] Ecology does not know how Euroglas overcomes this problem. It is possible that Euroglas' product differs significantly from Cardinal's such that SO_2 emissions are substantially lower, its furnace design may recover less heat than Cardinal's (thereby allowing use of medium-temperature SCR), or Euroglas may use much more intensive SO_2 removal than would be considered BACT by Ecology. In any case, Ecology cannot consider the Euroglas installation to be adequate evidence that SCR is available technology, readily applicable to Cardinal's glass furnace.

This conclusion is supported by Ecology's communication with Denish Bhusan of Durr Environmental, an SCR system vendor[28]. Mr. Bhusan referred to Durr's attempt to install an SCR system on a General Electric (GE) quartz glass furnace. He said the result was "a fiasco," and that Durr is currently negotiating a non-performance settlement with GE. GE was ultimately able to retrofit sufficient additional dust removal equipment ahead of the SCR system and incorporate a periodic blow-off technique to allow adequate operation of the system. However, the details are proprietary. Mr. Bhusan said, "Whether (GE's) solution could be adapted to a float glass facility is a matter of speculation." **Ecology concludes that SCR is not technically feasible for the proposed Cardinal facility**.

2.3.1.5 FENIX Process

[24] It would require enough natural gas to heat over 1,000 homes.
[25] IPPC, op. cit.
[26] Netherlands Emission Inventory Guidebook B3314-16 (September 1, 1999)
[27] ibid., page 167
[28] 11/19/03 telephone conversation between Denish Bhusan, Durr, and Bernard Brady, Ecology

The FENIX™ process is a relatively new and proprietary NOx emissions control technique. It has only been fully developed on one furnace, the Saint-Gobain float glass line in Aniche, France. The NOx concentration has been reduced from 820 ppmdv to 297 ppmdv, a reduction of 63 %. Saint-Gobain is apparently willing to grant a non-exclusive license under FENIX technology to other glassmakers, provided that an agreement can be reached on the conditions of such license. Its application requires complete modification of the standard float glass combustion system and particularly the use of a new type of injectors. For each furnace, the technique requires careful application by a specialized team. **Ecology concludes that the FENIX Process is not sufficiently demonstrated to be considered technically feasible for the proposed Cardinal facility**.

2.3.1.6 Chemical Reduction by Fuel (CRF), 3R Process™

The 3R Process is licensed by Pilkington UK Ltd.[29]. There are at least seven float glass plants using the 3R Process permitted or operating in Europe (earliest ca. 1995), and six in the United States (earliest ca.1998). Cardinal is using the 3R Process in two of its other plants: Mooresville, N.C. and Durant, OK. By all indications from the available literature, the 3R Process is considered to be the current industry standard for NO_X control in float glass furnaces.

The general principal of the 3R Process is that excess fuel is fed to the furnace to cause an oxygen-starved condition in critical phases of the combustion process. With no waste heat recovery on the plant, the extra fuel required is generally around 5% to 12% of the melting energy[30].

There are two main stages involved in the 3R process, $deNO_X$ and burnout. In the $deNO_X$ stage there are two principle mechanisms. The first involves reaction between incompletely oxidized fuel and nitric oxide (NO). The second mechanism occurs as the waste gases pass down through the regenerator checkerwork. The CO and hydrogen (formed during the incomplete combustion phase) have adequate time in the checkerwork at a high enough temperature to reduce the majority of the remaining NO to nitrogen. The second stage of the process involves the burnout of reduced species, mainly unreacted CO and hydrogen. The degree to which the later is accomplished depends on furnace design.

There is a concern that the reducing atmosphere created in the regenerators can damage some types of refractory materials. The unavoidable alternating cycles of reducing and oxidizing atmospheres in a regenerator-type furnace using 3R Technology can have serious consequences in furnace refractories[31]. Most experience with the 3R Technology has been gained with float glass furnaces, which tend to use high quality refractory materials in the regenerators. Early failure of refractory materials would require rebuilding the furnace. This would involve substantial costs not only in reconstruction but in lost production. Since the normal life of a float glass furnace is at least 12 years, and float glass furnaces rarely shut down completely during that period, it can take years to determine whether there has been refractory damage.

[29] Prescot Road St Helens WA10 3TT United Kingdom
[30] Electronic mail communication between Ian Shulver (Pilkington UK Ltd.) and Bernard Brady (Ecology), February 11, 2004.
[31] "Complex Phase Equilibria in Refractories Design and Use," op. cit.

The degree of NO_X reduction achieved with 3R depends mainly on the amount of extra fuel added, and can be tailored to meet various emission standards. In other words, the 3R Process is a tune-able NO_X control technology. Consequently, operators of float glass furnaces using the 3R Process would not be expected to operate much below their regulatory requirement[32]. Nonetheless, float glass furnaces have reported to their regulatory agencies operation below 3 pounds NO_X per ton glass draw (lb NO_X/T_G) in the U.S. and Europe for periods of up to a year and routine operation below 5 lb NO_X/T_G in Europe and 6 lb NO_X/T_G in the U.S. for over a year[33].

Cardinal proposed application of the 3R Process with a permit limit of 7 lb NO_X/T_G. Cardinal said it is concerned that more intensive use of the 3R Process to achieve lower NO_X emission levels might cause early refractory failure of the float glass furnace. According to information from the leading float furnace refractory supplier, Saint-Gobain Ceramics, there are at least two float glass plants in the U.S. and two in Europe are undergoing extensive furnace repair that they claim is due to using the 3R Process[34]: Guardian Industries in Geneva, NY, AFG Industries in Richmond, KY [35], Guardian Industries in Luxembourg, and Pilkington in Germany. Saint-Gobain is currently conducting research and demonstration projects to improve refractory formulation relative to deleterious effects of the 3R Process[36]. In addition, Cardinal showed Ecology examples of decomposing refractory from its Mooresville float glass plant[37]. The Mooresville plant reported operating between 4 and 5.4 lb NO_X/T_G for the years 2002 and 2003[38]. The Mooresville plant has been in operation since 1999. Cardinal indicated they anticipate having to rebuild the furnace within two years due to accelerating refractory decomposition[39]. This would mean that the Mooresville furnace "campaign" was cut short at seven years, slightly longer than 50% of the normally expected furnace life. Cardinal has modified the furnace design[40] for the Winlock facility and plans to install a modified refractory formulation. However, these modifications have not been demonstrated in practice to significantly improve 3R-related refractory decomposition.

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[32] Ibid.

[33] (1) IPPC, op. cit., (2) Shulver, Ian, "Pilkington 3R™ Process: A Refractory Perspective," The American Ceramic Society Bulletin (May, 1999), (3) Shulver-Brady electronic communication (February 4, 2004), (4) Source test reports from North Carolina Div. of Air Quality, (5) Source test reports from Toledo (Ohio) Division of Environmental Services, (6) Continuous Emissions Monitoring data from Mojave Dessert Air Quality Management District.

[34] Michele Blackburn, Regenerator Systems Manager - North and South America (Saint-Gobain Ceramics, Louisville, KY) to Ken James, Cardinal FG, "…experience and use of the 3R process for NO_X emissions control in the glass industry" (March 26, 2004)

[35] Confirmed by telephone and electronic communication between Bernard Brady and New York Department of Environmental Conservation (October, 2003) and Kentucky Division of Air Quality (February, 2004)

[36] Telephone conversation (April 15, 2004) between Allen Davis (Saint-Gobain Ceramics) and Bernard Brady (Ecology)

[37] Meeting between Cardinal representatives and Ecology (April 15, 2004)

[38] Op. cit.: Source tests and emission inventory reports to NCDAQ.

[39] Op. cit.: 4/15/04 Cardinal - Ecology meeting.

[40] Klafka, Steven (Wingra Engineering) to Bernard Brady (Ecology), "Response to November 24th for Information, Air Quality Permit Application, Cardinal FG Company Glass Plant Project Lewis County, Washington," page 4 (January 8, 2004)

Early refractory failure can occur as a result of accumulated slag that is not properly cleaned from furnace checkers[41]. Ecology has no information on the frequency of occurrence of refractory failure in float glass furnaces that do not use the 3R Process. The previously cited study by Ian Shulver (American Ceramic Society Bulletin, 1999) investigated refractory from three float glass plants that had been using the 3R Process for up to 4 years at that time with NO_X emissions below 5 lb NO_X/T_G. The report concluded, "3R technology has no affect on the furnace structure and, therefore, the campaign life[42]." In the previously cited electronic communication between Ian Shulver and Bernard Brady (February 4, 2004), Mr. Shulver updated this conclusion. He said he knew of no float glass furnaces wherein early refractory failure had been confirmed to be caused by application of the 3R Process.

Ecology cannot ignore Cardinal's concern about the possibility of refractory damage by application of the 3R Process. There is significant evidence from the U.S. and Europe that float glass furnaces using the 3R Process are experiencing early refractory damage. In the face of this evidence, Ecology has little choice but to conclude that NO_X emission levels lower than 7 lb NO_X/T_G using the 3R Process are not currently technically feasible. **Ecology concludes that 7 lb NO_X/T_G using the 3R Process is technically feasible**. This would constitute a NO_X reduction of 48%.

2.3.1.7 Air Staging including Oxygen Enhancement (OEAS):

Splitting combustion air into zones in furnaces and boilers is an old, cost-effective technique used to reduce NO_X emissions. In solid fuel combustion, it is often referred to as using overfire and underfire air[43]. The general idea is to inhibit NO_X formation by initiating fuel-firing with insufficient oxygen for complete combustion (sub-stoichiometric oxygen level). The remaining necessary air (oxygen) is introduced later in the combustion chamber where the combustion gasses are cooler. This allows burning off the excess CO and VOCs at lower temperatures that do not favor NO_X formation.

Gas Technology Institute (GTI) has been working with Combustion Tec Division of Eclipse Combustion, Inc to develop and introduce an oxygen-enhanced version of air staging[44], "Oxygen Enhanced Air Staging (OEAS)." Atmospheric combustion air is introduced at a sub-stoichiometric level in the high temperature flame zone of the glass furnace, and oxygen-enhanced air is introduced near the exit ports to complete combustion. The result is a mechanism that inhibits NO_X formation in a similar manner to the widely used air-staging technique described above. In principal, enhancing the secondary air with oxygen should decrease overall fuel consumption while allowing a more aggressive inhibition of NO_X formation in the primary combustion area. Because the oxygen is added in the cooler section of the furnace, refractory decomposition experienced in oxy-firing should be less pronounced.

GTI reports that ten container glass plants have been successfully converted to OEAS with NO_X reductions of 40% to 70% from uncontrolled levels (averaging periods not

[41] EPA AP-42, Glass Manufacturing, Chapter 11.15, §11.15.2 (1986)
[42] "Campaign life" is the term used in Europe to refer to the length of time between furnace shutdowns.
[43] "Advanced Furnace Air Staging and Burner Modifications for Ultra-Low NO_X Firing Systems," McCarthy, Laux, and Grusha; Foster Wheeler Energy Corp. (ca. 1999)
[44] Gas Technology Institute Focus Fact Sheet, 1700 S. Mount Prospect Rd., Des Plaines, IL (July, 2003)

specified). No float glass installations or conversions have yet been made. However, GTI is actively marketing OEAS to all glass sectors. If NO_X reduction levels may be expected to be in a similar range for float glass plants, OEAS would have a similar efficacy to the 3R technology.

Because OEAS has not been demonstrated in float glass furnaces, Ecology cannot conclude that it passes the standard for technical feasibility for Cardinal-Winlock. However, **Cardinal proposed to modify the design of the Winlock furnace to allow for use of OEAS** in the event experience with 3R Technology indicates it must be abandoned due to the severity of refractory decomposition. Cardinal proposed that in the event they switch to OEAS, **they will comply with the same permit limits for NO_X emission levels determined as BACT** in this permit action. **Ecology agrees with this proposal.**

2.3.1.8 Selective Non-catalytic Reduction (SNCR)

In absence of the problems discussed below, SNCR could have a NO_X control efficiency approximately equivalent to the 3R Process. There may have been two float glass plants installed in the U.S. originally with SNCR (AFG Industries, Victorville, CA and PPG, Fresno, CA).

The previously referenced IPPC report concluded that SNCR should be 30% to 70% effective for NO_X reduction with the lower end more likely for regenerative furnaces, and that "ammonia injection within the correct temperature window is … sometimes difficult or impracticable to achieve (particularly for regenerative furnaces)". Flat glass is made in regenerative furnaces. In addition, a characteristic potential problem with all SNCR applications is reaction of any excess ammonia with NO_X and sulfur oxides. The resulting salts form fine particulate aerosols that give a visible plume from the exhaust stack that is usually in excess of regulatory limits on exhaust stack emission opacity.

The AFG float glass plant in Victorville, CA was originally permitted at 6.5 lb NO_X/T_G (24 hour average)[45]. The AFG facility was never able to bring exhaust stack emission opacity problems under control while maintaining compliance with the permit limit on NO_X emissions. In 2000, Mojave Dessert Air Quality Management District (MDAQMD) gave AFG approval to decommission the SNCR system and install 3R controls[46]. MDAQMD issued a new permit to AFG based on use of 3R controls with emission limit of 8.7 NO_X/T_G (24 hour average) and 6.2 lb NO_X/T_G assuming 359 days per year NO_X controlled-operation at full production capacity.

There is no record in either EPA's[47] or California's[48] permit data base of the PPG-Fresno facility being constructed with the intent to apply SNCR. The reference to it is taken from the previously-cited IPPC report. In any event, the PPG-Fresno facility was permitted in 1996 by the San Joaquin Valley Unified Air Quality Management District (SJAQMD) to use a "supplemental burner system" with a 7.7 lb NO_X/T_G emission limit. As cited in

[45] MDAQMD Permit No. SE 8602 (12/08/1986); EPA RBLC ID CA-0182 (http://cfpub1.epa.gov/rblc/cfm/basicsearch.cfm)
[46] Telephone communication between Alan DeSilvio (MDAQMD) and Bernard Brady (November, 2003).
[47] U.S. Environmental Protection Agency Technology Transfer Network, Clean Air Technology Center, RACT/BACT/LAER Clearinghouse (http://cfpub1.epa.gov/rblc/cfm/basicsearch.cfm)
[48] California Best Available Control Database (http://www.arb.ca.gov/bact/bactsearch.htm)

§2.3.1.3, PPG-Fresno recently converted to oxy-fuel melting. Consequently, it appears there are no float glass plants in the U.S. (and perhaps none in the world) using SNCR for NO_X control. **Ecology concludes SNCR is not technically feasible for the proposed Cardinal facility**.

2.3.1.9 NO_X BACT Determination

All the remaining BACT candidates in Table 3 have a lower potential for NO_X removal for Cardinal's glass furnace than application of the 3R Process, and will not be further considered. As noted in §2.3.1.6, Ecology concludes that application of the 3R Process to Cardinal's glass furnace with a limit of 7 lb NO_X/T_G is technically feasible. Cardinal proposed this as BACT, and further proposed using OEAS to achieve BACT if refractory deterioration concurrent with 3R Technology proves intractable. Consequently, this represents "top-case," and no further analysis is required.

According to Cardinal, all float glass furnaces experience deposition of sulfate salts in the refractory checkers whether using the 3R process or otherwise. The sulfate deposits are periodically burned out by raising the furnace checker temperature over a period of 7 to 10 days followed by 3 to 4 days of cleanout[49]. In order to accomplish the furnace burnout, the 3R Process must be off-line. NO_X emissions are uncontrolled at that time. Cardinal indicated the first such burnout should take place about two years after startup, but will be at an increasing frequency as the furnace ages. In the later years of the furnace useful life, the burnout may be required as much as twice in any twelve month period.

Ecology determines that BACT for the proposed Cardinal-Winlock glass furnace is a NO_X emission limit exclusive of burnout-maintenance operation of 7 lb NO_X/T_G (24-hour average basis),

Ecology further determines that burnout-maintenance is periodically necessary, and standard in the industry. BACT is no more than two such periods annually of not greater than fourteen days each during which NO_X emissions are limited to 13.3 NO_X/T_G (averaged over each burnout-maintenance period). See §4.1 for restrictions on times of the year when burnout-maintenance may be done.

Further, to assure NO_X control performance consistent with the Class I area protection indicated by the modeling provided in Cardinal's PSD application, **NO_X emissions will also be limited to 4,521 pounds in any 24 consecutive hours exclusive of burnout operation, measured by continuous emissions monitoring.**

2.3.2 CARBON MONOXIDE

There are two processes that might be applied for controlling CO emissions from flat glass furnaces:

- CO Combustion Catalysis
- Good Combustion Practice

2.3.2.1 CO Combustion Catalysis

[49] Ecology confirmed this during the previously referenced February 26, 2004 telephone communication with John Stoffel of the Wisconsin Department of Natural Resources.

CO combustion catalysis is similar to SCR in that the CO is destroyed by oxidizing it to carbon dioxide by passing it over a solid catalytic bed at a temperature between about 700 ^{o}F and 1,300 ^{o}F. The conventional catalyst is a noble metal, such as platinum or palladium on a ceramic surface. Ecology was unable to find evidence that CO combustion catalysis has been applied to CO control for a float glass furnace.

As with the low temperature SCR catalyst, CO combustion catalyst systems are susceptible to sulfur and particulates, and have most frequently been used in installations firing natural gas with a clean combustion exhaust. All the problems discussed in §2.3.1.4 for low-temperature SCR apply to an even greater degree using CO combustion catalysis for a glass furnace. **Consequently, Ecology concludes CO combustion catalysis is technically infeasible for the proposed Cardinal-Winlock glass furnace.**

2.3.2.2 Good Combustion Practice

Good combustion practice consists of maintaining an adequate air supply in the secondary combustion "burnout" section of the furnace to oxidize as much of the CO as possible within the restriction of the furnace design. There is very little in the literature about what level of CO emissions may be expected in conjunction with the application of the 3R Process. European literature suggests that CO is not given the same weight of importance as an air pollutant as in the U.S., and appears to assume that CO emission levels are relatively unaffected by the 3R Process[50].

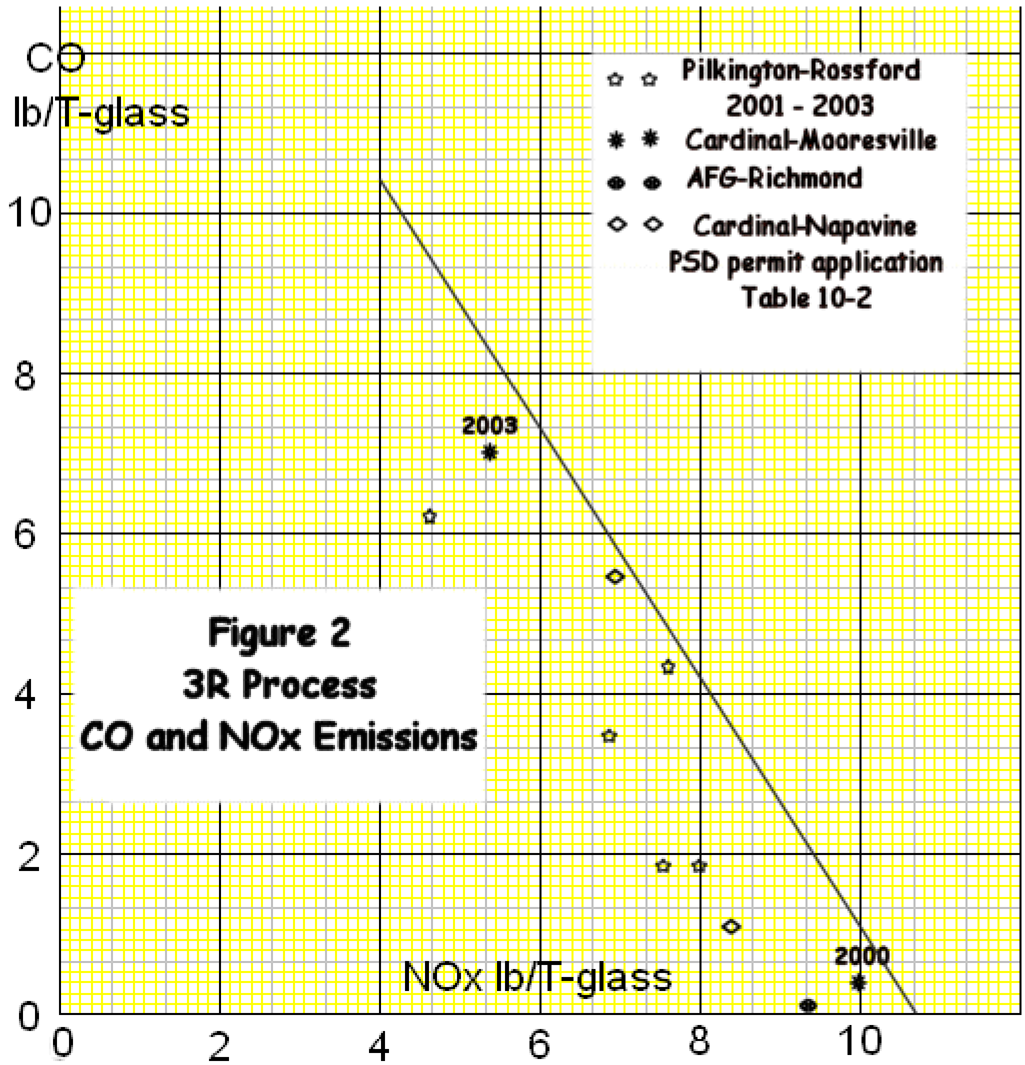
Recent permit decisions in the U.S. for glass furnaces appear to have started out with the same assumption. As noted in §2.3.1.6, the NO_X control effectiveness of the 3R Process increases as excess fuel is fed to the glass furnace. It appears that as NO_X is reduced to levels below about 9 to 10 lb NO_X/T_G, CO emissions increase rapidly. Given the nature of the mechanism of the 3R Process (rich fuel feed), increasing CO emissions with decreasing NO_X emissions is a reasonable expectation. With the exception of Cardinal's Durant, OK facility (permitted in 2003), all glass furnaces in the U.S. built to use the 3R Process were either permitted with no CO emission limit (because CO emissions were expected to be below PSD significance) or at the EPA AP-42 emission factor[51] of about 0.1 pounds CO per ton glass draw (lb CO/T_G). The AP-42 CO emission factor does not reflect use of the 3R Process.

Cardinal's Durant, OK facility is permitted at 10 lb CO/T_G. North Carolina Div. of Air Quality (NCDAQ) recently amended the CO emission limit in Cardinal's Mooresville permit. The new CO emission limit is 10 lb CO/T_G[52]. This is intended to account for higher, uncontrollable CO emissions that result from increased excess fuel use for the 3R Process needed to comply with NO_X emission limits at 7 lb NO_X/T_G. TDES is analyzing

[50] "Integrated Pollution Prevention and Control (IPPC) Guidance for Glass Manufacturing Activities with Melting Capacity More than 20 Tonnes /Day,"§2.3.3.4, Sector Guidance Note IPPC S(A2)6.02, Environmental Protection National Service (Bristol, United Kingdom)
[51] op. cit., Table 11.15.2
[52] "Stack Test Report, Cardinal FG, Mooresville, North Carolina, Iredell County, 03/49/00261-A, Air Permit No. 08618T04," NCDAQ Memorandum from Heather Callahan to Shannon Vogel (July 23, 2003)

source tests on CO emissions from the Pilkington-Rossford facility (also using the 3R Process) to determine an appropriate correction to that facility's CO emission limit[53].

Cardinal suggested a CO emission limit for the proposed Winlock facility at 10 lb CO/T_G based on the rational that Cardinal's Durant, OK and Mooresville, NC glass furnaces have been permitted at that level. Based on source test data acquired from NCDAQ, TDES, and Kentucky Division of Air Quality (KDAQ), and data in Cardinal's PSD application for the proposed Winlock facility[54], Ecology believes this emission limit was set as a default, in absence of sufficient information. Figure 2, below, shows the apparent relationship between CO emissions and the 3R Process NO_X control level.



It is apparent from Figure 2 that an emission limit of 10 lb CO/T_G for the NO_X control level determined as BACT by Ecology is unjustified. **Ecology concludes**

[53] Telephone communication between Pam Barnhart (TDES) and Bernard Brady (November 11, 2003) and written communication from Pam Barnhart to Bernard Brady (November 13, 2003)

[54] PSD Air Quality Permit Application for Cardinal FG Glass Plant Project, Napavine, Washington (October 22, 2003), Table 10-2, "Relationship NO_X between and CO Emissions using the 3R Process"

- **BACT for CO control under use of the 3R Process for the proposed Cardinal-Winlock glass furnace is good combustion practice.**
- **The corresponding BACT-CO emission limit is 6.5 lb CO/T_G (twelve month rolling-average basis).**

Should Cardinal decide to abandon use of 3R Technology, and convert to use of OAES for NO_X control, this permit requires submittal of a request for permit amendment to evaluate corresponding appropriate CO emission limits.

2.3.3 SO_2

The largest source is the glass furnace. It originates from sulfur contained in the fuel and evaporated from the raw material. A smaller amount of SO_2 is emitted from the lehr (see §2.4). Essentially all technically demonstrated methods for removing SO_2 from exhaust gas involve chemical scrubbing. The exhaust stream is passed counter-currently through a falling stream of an alkaline absorbent. The absorbent is usually either Na_2CO_3, sodium bicarbonate, calcium oxide, or calcium hydroxide in either aqueous solution, slurried, or dry form. The SO_2 reacts with the absorbent to form the corresponding salt. This salt is a solid material that must be removed by an appropriate particulate removal method.

According to the previously cited IPPC report[55], the most common method used by European glass makers is the dry-process in conjunction with an electrostatic precipitator. Most European glass makers' SO_2 scrubbing systems use dry lime, and achieve an SO_2 reduction of around 50%.

It appears that higher efficiencies can be achieved if the exhaust gas temperature can be reduced below about 400 ^oF. The only way this is done on a practical basis is to slurry or dissolve the absorbent in water. The water evaporates and cools the hot exhaust gas during the absorption process. Practically speaking, this is only done when the absorbent is Na_2CO_3 because the sodium sulfite/sulfate effluent can be fed back with the raw materials to make up the necessary flux material. Consequently, the SO_2 emission control process is integrated with the glass making process, and the amount of water used in the Na_2CO_3 slurry must be correspondingly balanced. In addition, excess water causes corrosive condensation in the scrubber and recycle systems[56]. Only a few furnaces in Europe are equipped with semi-dry scrubbing devices (i.e., using the absorbent in a slurry), and none are known to use the absorbent in a fully dissolved form. The IPPC report says that the emissions concentration from these systems is about 74 ppmdv.

Ecology knows of only four float glass makers in operation in the U.S. using SO_2 control on glass furnace stack emissions[57]. All are "semi-dry" processes using Na_2CO_3. Cardinal proposed to use this system for SO_2 control at the Winlock facility. In addition to treating SO_2 emissions from the furnace, Cardinal proposes collecting SO_2 emissions from the

[55] IPPC, op. cit.

[56] Telephone communication between John Stoffel, Wisconsin Department of Natural Resources, and Bernard Brady (February 26, 2004)

[57] In essentially all float glass plants, the glass maker is restricted by permit terms on the sulfur content of the salt cake, a raw material. Cardinal-Winlock will have a continuous emissions system to monitor SO_2 emissions from the glass furnace stack. Consequently, limiting the sulfur content of the salt cake is unnecessary to monitor continuous compliance with the BACT determination.

lehr section of the process via a ventilation hood and routing them through the spray dryer/ESP system used for glass furnace emissions. Permitted emission limits for the existing U.S. glass making facilities having SO_2 emissions control are shown in Table 4, below:

Table 4: SO_2 Emission Limits from Glass Furnaces for U.S. Float Glass Manufacturers

Source	Year permitted	SO_2 Emission Limit		
		lb SO_2/hr	lb SO_2/MBtu	ppmdv
Cardinal-Portage, WI	1999	17.6	0.11	37
Cardinal-Menomonie, WI	1994	15	0.1	33
AFG-Victorville, CA[58]	1986	15	0.1	33
PPG-Mt. Zion, IL	1994	28	0.14	46

Cardinal-Menomonie has been able to comply with this limit since at least 1993[59]. According to John Stoffel, (WDNR), "Cardinal has very good learning experience on this process." Cardinal-Portage was permitted in 1999 at 17.6 lb SO_2/hr. This is equivalent to 0.088 lb/MBtu or 35 ppmdv. Cardinal proposed an emission limit of 16.3 lb SO_2/hr for as BACT Cardinal-Winlock. This is equivalent to 0.082 lb/MBtu or 32 ppmdv, and is a 70% removal efficiency. Since this appears to meet or exceed the lowest demonstrated SO_2 emission limit for a float glass plant, **Ecology agrees that 32 ppmdv expressed as 0.6 lb SO_2/ T_G (3-hr average) is BACT for the proposed Cardinal-Winlock glass furnace**.

2.3.4 Particulate Matter

Particulate matter emissions have two components: Filterable material (usually chemically inorganic in a glass plant, and sometimes referred to as "dust") and "condensable" material. Technically, filterable particulate is solid at the stack temperature. Practically, it is material that is solid at the temperature at which it is removed from the exhaust stream, and large enough in aerodynamic size to be captured by a 0.3 micrometer (µm) filter[60]. Condensable particulate is either a vapor at the stack temperature or is a solid, but too small to be captured on the 0.3 µm filter. To determine the amount of condensable particulate in exhaust gas, sampled gas is bubbled through a series of cold water baths after having passed through the filter. Any vapor material that will condense at or above the bath temperature as well as particulate smaller than 0.3 µm is captured for gravimetric analysis[61].

The highest efficiency devices for particulate removal from gas streams are

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[58] This is taken from the Title V permit issued by the Mojave Dessert AQMD (B001726, expires "last day of January, 2004). The entry of 10.5 lb SO_2/hr (3-hr average) shown in the EPA's data base is apparently in error.

[59] "Department of Natural Resources, West Central Region, Full Air Compliance Evaluation (FCE) Summary," Cardinal FG Menomonie, WI, John Stoffel – WDNR (September 25, 2003) and "Review of Cardinal Glass NO_x and SO2 RATA tests conducted 11 MAR 97," Correspondence/Memorandum, State of Wisconsin, File Ref: 4530, John Stoffel, P.E. (May 6, 1997)

[60] Reference Method (RM) 5, 40 CFR Part 60, Appendix A or RM 201/201A, USEPA Technology Transfer Network Emission Measurement Center, Category A

[61] RM 202, USEPA Technology Transfer Network Emission Measurement Center, Category A

- Fabric filters (baghouses) and
- Electrostatic precipitators (ESP).

If the application is appropriate, baghouses can generally be designed to higher capture efficiencies than ESPs. This is especially true if the exhaust stream can be cooled sufficiently to condense the organic fraction of the condensable particulate. An ESP is not effective on either organic particulate or particulate smaller than about 0.1 µm. A baghouse can capture both. However, a baghouse specifically designed to capture extremely small solid particulate is likely to experience a high pressure drop and/or high bag cleaning frequency[62]. And, organic particulate is usually polymeric and "sticky." The sticky character of organic particulate may exacerbate any tendency toward rapid blinding of fabric filters used for glass furnace emission treatment.

According to the IPPC report[63], baghouses are used for many applications within the glass making industry. They are widely used in conjunction with electric furnaces, stone wool cupolas, frit furnaces and ceramic fibre furnaces. In some smaller fossil fuel fired glass furnaces, baghouses have been chosen as the technique to operate with SO_2 dry scrubbing systems discussed in §2.3.3. However, due to their potential to blind, they have not been the preferred choice for particulate removal from float glass furnaces. As described in §1.2.2, the glass sheet formation process occurs in the furnace itself. If a baghouse is used for controlling particulate emissions from the float glass furnace, varying back pressure and disruptive blinding of the bags may affect product quality. The IPPC report says there may be one float glass plant in the world using baghouses for particulate control on furnace exhaust, but did not identify it. Ecology has been unable to identify it or confirm its location, let alone acquire any details of its size, effectiveness, or operating conditions. The ESP is clearly the predominant particulate control technique used for float glass furnace emissions. In absence of sufficient evidence of the application of baghouses to control particulate matter emissions from float glass furnaces, **Ecology concludes that baghouses are not technically feasible for the proposed Cardinal-Winlock glass furnace.**

The ESP is capable of operating over a wide range of conditions of temperature, pressure and particulate burden. There are wet and dry ESPs. In a wet ESP, water is sprayed down through the electrode channels to wash off sticky particulate. There is no indication in the EPA's or California's permit data bases or in the IPPC report[64] of wet ESPs having been used for particulate control on glass furnace exhaust. Ecology has only been able to find examples of wet ESPs being used on forest product drying operations, grain mills, and similar sources. In all of these, the exhaust stream is below 200 ^{o}F. Cardinal-Winlock's proposed glass furnace exhaust will be about 354 ^{o}F. Consequently, it would be difficult to estimate the potential effectiveness of using a wet ESP on glass furnace exhaust. In addition, the effluent from a wet ESP is a relatively dilute solution/suspension of the

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[62] "Economic Comparison of Emission Control Systems for Glass Manufacturing Furnaces with Heat Recovery," A. C. Caputo and P. M. Pelagagge, Journal of Air and Waste Management Association Volume 51, page 1012 (July, 2001)
[63] IPPC, op. cit.
[64] U.S. EPA RACT/BACT/LAER Clearinghouse; California Best Available Control Database; IPPC, op. cit.

particulate. As discussed in §2.3.3, this solution is corrosive, and likely to damage the control and process equipment unless additional precautions were incorporated in the overall design. Use of a wet ESP in conjunction with the SO_2 scrubber would also defeat one of the purpose of the scrubber, namely, to recover sodium sulfite/sulfate for recycle to the raw materials. The dilute aqueous solution could not be directly re-introduced to the glass furnace. For these reasons, **Ecology concludes that application of a wet ESP for control of particulate emissions from glass furnace exhaust is** highly speculative, outside the bounds of reasonable technology transfer, and **technically infeasible for the proposed Cardinal-Winlock glass furnace.**

Dry ESPs (hereafter simply "ESPs") are widely used to remove particulate material from glass furnace exhaust. There is no dispute that they are technically feasible for the proposed Cardinal-Winlock glass furnace.

The ESP consists of a series of high voltage discharge electrodes and corresponding collector electrodes. Particles are charged and subsequently separated from the gas stream under the influence of the electric field generated between the electrodes. The electrodes must be rapped or vibrated to prevent material build-up. ESPs are very effective in collecting dust in the range 0.1 µm to 10µm, and overall collection efficiency can be 95 - 99% (depending on inlet concentration and ESP size). According to the Cardinal-Winlock PSD application[65], at least one supplier of ESP systems has developed an ESP system "specifically for the glass industry using narrower spacings between the plates" (United McGill Corporation, 1779 Refugee Road, Columbus, OH). In most applications a modern well designed two or three stage ESP could be expected to achieve 0.009 grains per dry standard cubic foot (gr/dscft) and less than 0.2 lb filterable particulate per ton of glass melted (lb PM_F/T_G)[66].

Ecology knows of nine float glass makers in operation and one under construction in the U.S. using an ESP to control glass furnace filterable particulate emissions. Permitted emissions limits for these facilities are shown in Table 5, below. All other float glass plants shown as permitted in the EPA's data base[67] have no post-process particulate emissions control.

Table 5: Particulate Emission Limits from Glass Furnaces for U.S. Float Glass Manufacturers

Source	Year permitted	Particulate Emission Limit		
		lb PM/hr	gr/dscft	lb PM/T_G
Cardinal-Durant, OK	2003	40.6 total	0.05 filterable	1.0 filterable
Cardinal-Portage	1999	25.5 total	0.06	0.98
Cardinal-Portage	1994	5.5 filterable 25.5 total	0.014 0.07	0.20 1.0
PPG-Fresno, CA	1996	19.2 total	0.053	0.88
PPG-Mt. Zion	1994	7.2 filterable	0.014	0.23
Cardinal-Menomonie	1991	5.5 filterable	0.014	0.20

[65] Cardinal-Winlock PSD application (October 22, 2003), op. cit., page 26
[66] IPPC, op. cit.
[67] U.S. EPA RACT/BACT/LAER Clearinghouse, op. cit.

Source	Year permitted	Particulate Emission Limit		
		lb PM/hr	gr/dscft	lb PM/T_G
(originally AFG)	revised 2002	25.5 total		
U.S Glass-Donoro, PA	1990	3.0 filterable	0.007	0.13
AFG-Victorville	1986	Not specified	0.02	Not specified
Guardian-Kingsbury, CA	1981	12.2 filterable	0.02	0.39
PPG-Mt. Zion	1980	18.7 filterable	0.03	0.6

Cardinal proposes to apply an ESP to reduce filterable particulate emissions from the exhaust stream from the glass furnace to an emission limit of 2.44 lb/hr. This is equivalent to an emission concentration of 0.005 gr/dscft and an emission rate of 0.09 lb PM_F/T_G. When considering the total particulate load generated by the SO_2 scrubber and directly from the glass furnace, the ESP would be 99% efficient. This appears to meet or exceed the lowest demonstrated filterable particulate emission limit for a float glass plant. **Ecology agrees that 2.44 lb PM_F/hr expressed as 0.09 lb PM_F/T_G (24-hr average) is BACT for the proposed Cardinal-Winlock glass furnace**.

As noted above, ESPs have an approximate lower effectiveness limit relative to particulate size of about 0.1μm, and are relatively ineffective on organic particulate. Cardinal estimated that there will still be about 23 lb/hr "condensable" particulate in the glass furnace exhaust after it has passed through the ESP. There are no glass furnaces shown in either the EPA or California permit data base to which any technology has been applied for control of particulate passing through an ESP. It is necessary to examine the characteristics of the glass furnace exhaust at this point in order to assess the possibility of application of technology transfer.

Based on organic/inorganic speciation tests performed at the Cardinal-Mooresville plant[68] and source tests from Cardinal's Portage[69] and Menomonie[70] plants, Ecology estimates that the composition of the particulate passing the ESP is about 95% inorganic. The inorganic fraction is likely to be Na_2CO_3 and sodium sulfite/sulfate from the SO_2 scrubber. Because it passes through the 0.3 μm filter, it is substantially smaller than 0.3 μm in size, and may be smaller than 0.1 μm when considering the ESPs capabilities. Wet ESPs have been applied to capture very small particulate from forest product drying and grain milling. However, as noted above, this would be a highly speculative application for glass furnace exhaust. Ecology previously rejected baghouses as technically infeasible for this exhaust stream. Consequently, Ecology knows of no technology-transfer that might be expected to effectively further reduce the concentration of this extremely fine inorganic "condensable" particulate from the glass furnace exhaust**. Ecology concludes there is no technically feasible control technology beyond the proposed ESP to further reduce the emissions of the inorganic fraction of the "condensable" particulate in the exhaust from the Cardinal-Winlock glass furnace.**

The organic fraction of a source' condensable particulate is often referred to as "condensable volatile organic compounds." There is no indication in the EPA's or

[68] March 7, 2000 tests performed at Cardinal-Mooresville by ESS Samplers.
[69] August 8, 1999 and August 29, 2001; Cardinal-Portage.
[70] "Review of Cardinal Glass CO and Particulate tests conducted 12 MAR 97," Correspondence/Memorandum, State of Wisconsin, File Ref: 4530, John Stoffel, P.E. (May 6, 1997)

California's permit data bases or in the IPPC report[71] of application of post-process condensable-VOC controls on glass furnace exhaust. Condensation or adsorption processes have been used in some industrial processes to remove VOCs from exhaust streams when the concentration is high enough. The lower limit for practical application is about 1,000 ppmdv. Ecology estimates the concentration of the remaining organic fraction of the condensable particulate to be about 0.001 gr/dscft. Assuming for the sake of illustration that the average condensable VOC is a low molecular weight polymer with a molecular weight of 300 pounds per pound mole, 0.001 gr/dscft is equivalent to about 6 parts per *billion*. In other words, the concentration of condensable VOCs in Cardinal's proposed glass furnace exhaust is less than one-100,000th the lower limit for practical application of condensation or adsorption. **Ecology concludes there is no technically feasible control technology to further reduce emissions of the organic fraction of the "condensable" particulate in the exhaust from the Cardinal-Winlock glass furnace.**

In summary, **Ecology concludes that BACT for the "condensable" particulate in the exhaust from the Cardinal-Winlock glass furnace after passing the ESP is no further treatment with an emission limit of 23 lb/hr expressed as 0.85 lb PM_C/T_G (24-hr average).**

2.3.5 Volatile Organic Compounds

Cardinal's proposed glass furnace also emits volatile organic compounds (VOCs) that are not condensable at ordinary temperature and pressure. The most commonly used, EPA-approved test method for VOCs, should measure both the condensable and non-condensable VOCs[72]. If there is a control technology that will successfully reduce non-condensable VOCs in the glass furnace exhaust, it will also reduce condensable VOCs.

There is no indication in the EPA's or California's permit data bases or in the IPPC report[73] of application of post-process VOC controls on glass furnace exhaust. The VOCs from Cardinal's proposed glass furnace are the result of incompletely oxidized natural gas. There is no indication in the EPA's or California's permit data bases of application of post-process VOC controls on combustion processes burning only natural gas except as a collateral benefit of CO combustion controls. Nonetheless, in the hope that a VOC control technology may be found to be applicable as a technology transfer from another source category, Ecology considered the following:

- Biofiltration,
- Direct in-stack combustion,
- Recuperative combustion
- Regenerative combustion (either thermal or catalytic), and
- Direct catalytic combustion.

[71] U.S. EPA RACT/BACT/LAER Clearinghouse; California Best Available Control Database; IPPC, op. cit.
[72] Reference Methods 25 A and 25B, 40 CFR Part 60, Appendix A
[73] U.S. EPA RACT/BACT/LAER Clearinghouse; California Best Available Control Database; IPPC, op. cit.

In general, VOCs in exhaust streams are controlled by either biofiltration or combustion with about 90% control efficiency or by recognized good combustion practice (the default control technology). Judging from a typical application reported in EPA's permit data base[74], biofiltration has been used on exhaust streams that are near room temperature, and when the VOC concentration is about 0.22 gr/dscft (267 ppmdv as propane). As noted previously, the exhaust stream from Cardinal's proposed glass furnace will be at about 354 ^{o}F. Cardinal estimated that total VOCs in the glass furnace exhaust will not exceed 2.7 lb/hr (0.006 gr/dscft or 8 ppmdv as propane). Biofiltration itself is a relatively new and innovative VOC control technology. Unless duplicating a previous application, its use is preceded by extensive testing to assure that the VOCs are digestible by the biofilter media. Applying it for VOC control on the Cardinal's proposed glass furnace exhaust in the face of large concentration and temperature differences and uncertainty about the VOC-biofilter media compatibility would be highly speculative. **Ecology concludes that application of biofiltration for control of VOCs from glass furnace exhaust is technically infeasible for the proposed Cardinal-Winlock glass furnace.**

VOC reduction by combustion can be done in several ways: Direct in-stack combustion, recuperative combustion, regenerative combustion (either thermal or catalytic), or direct catalytic combustion. It is certainly technically feasible to raise the exhaust stream to a high enough temperature (about 1600 ^{o}F) to complete the combustion of the VOCs. However, Ecology estimates the fuel cost alone would be about $325,000/ton VOC reduced. This is on the order of 100 times higher than the level Ecology would consider justifiable. Recuperative combustion involves incorporating heat exchange equipment in the duct work that will allow the hot exhaust gas after treatment to pre-heat the incoming gas. Practically speaking, this might reduce the fuel cost by up to one-fourth[75]. In that case, the fuel cost alone would still be over $80,000/ton VOC reduced.

Regenerative combustion uses ceramic material to capture some of the heat from the exhaust gas. It can either be direct thermal combustion or catalytically assisted. In the former case, the temperature of the exhaust gas must be raised to the same level as in direct or recuperative combustion. At the inlet side of the regenerative oxidizer, the exhaust gas is preheated by the hot ceramic, heated the rest of the way to combustion temperature by supplemental fuel burning, and then passed over another ceramic section to recapture some of the heat. The greater the number of ceramic sections, the greater will be the heat recovery. Any number of ceramic sections may be included in the design in accordance with a capital cost - fuel use trade-off. The ceramic sections are shifted as they cool or heat up in the process. Regenerative oxidizers can apparently be designed to reduce the supplemental fuel requirement by as much as 95%[76]. Even at this level, a regenerative *thermal* oxidizer would have an effectiveness cost of about $16,000/ton VOC reduced for the fuel alone. As with recuperative combustion, the fuel cost alone is sufficient to reject this alternative.

In regenerative *catalytic* combustion (RCO), a precious metal catalyst section is incorporated in the gas flow path. It is likely that an RCO will have the same technical

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[74] MS-0311, Weyerhaeuser-Grayling MS, U.S. EPA RACT/BACT/LAER Clearinghouse, op. cit.
[75] MEGTEC Systems, http://www.megtec.com/products/recuperative.htm
[76] Huntington Environmental Systems, http://www.huntington1.com/prod_rto.html

feasibility problems as discussed in §2.3.2.1 for catalytic CO combustion. But, for the sake of argument, Ecology will discount that likelihood in the following discussion.

The incorporation of a catalytic section in an RCO allows the VOCs to oxidize at a much lower temperature than in a thermal oxidizer, about 500-600 ^oF[77]. Since the exhaust gas from Cardinal's proposed glass furnace is expected to be about 354 ^oF, the fuel cost compared to non-catalytic oxidation could be substantially lower, about $3,150/ton VOC reduced. If this were the only cost, Ecology would conclude this to be economically justifiable. However, regenerative oxidizers are relatively expensive investments. Based on previous cost analyses performed or reviewed by Ecology for RCO[78], Ecology estimates the capital cost for an RCO for VOC treatment on Cardinal's proposed glass furnace exhaust would be about $3 million. Using the same amortization basis as presented in this project's PSD application for other control elements (20 year system life, 7%/year ROI) gives a capital return cost of about $24,000/ton VOC reduced. There are other operating costs, but the $27,000/ton VOC reduced calculated so far is sufficient to reject this alternative.

The final possible post-process VOC control technology is direct catalytic combustion. This is identical to CO combustion catalysis as described in §2.3.2.1. Ordinarily, VOC reduction is accomplished as a collateral benefit when a CO combustion catalyst system is incorporated in a source' emission control train. In any event, catalytic combustion applied for VOC control would be subject to the same potential inhibitions to technical feasibility as discussed in §2.3.2.1. In summary, **Ecology rejects all post-process VOC control technology candidates for the proposed Cardinal-Winlock glass furnace on either the basis that they are either technically infeasible or economically unjustifiable.**

Ecology concludes that BACT VOC control for the proposed Cardinal-Winlock glass furnace is good combustion practice with a VOC emission limit of 2.7 lb/hr expressed as 0.10 lb VOC/T_G (24-hr average).

2.4 LEHR - SO_2 EMISSIONS

The lehr is a roller hearth oven designed to cool the glass ribbon after it exits the furnace and adjacent tin bath. Since the lehr must prevent the formation of excessive stresses in the glass, cooling rates are controlled both across the width of the lehr and along its length. Once the glass leaves the tin bath, it is visible for approximately 4 feet, then enters the lehr. After 6 feet, SO_2 gas is injected on the rollers and the top and bottom surfaces of the glass to prevent staining. After another 6 feet, there is a small hood inside the lehr to capture unused airborne SO2 and return it to the delivery pipes for reuse. The lehr is enclosed so unused SO2 may only leave the lehr at the entrance opening facing the tin bath, or further down its 180 foot length through any small openings. SO_2 not retained by the glass or captured through the hood is released into the plant building as fugitive indoor emissions.

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[77] Huntington Environmental Systems, http://www.huntington1.com/prod_rco.html
[78] Washington Department of Ecology PSD 96-03 for Boise Cascade-Yakima (November 13, 1996) MS-0024, Weyerhaeuser-Philadelphia, MS (1995) and AL-0079, Weyerhaeuser-Millport, AL (1994); U.S. EPA RACT/BACT/LAER Clearinghouse, op. cit.

SO_2 emissions from the lehr have not been thoroughly investigated by the industry or regulatory agencies because it is believed they are relatively small in comparison to SO_2 emissions from the glass furnace. According to the IPPC report [79], "SO_2 is used at the beginning of the lehr (and) if the process is properly operated emissions are insignificant." Based on a similar belief, EPA's AP-42 offers no factor for SO_2 emissions from the lehr[80]. Source tests by KDAQ indicated uncontrolled SO_2 emissions from the lehr might vary from about 1% to 50% of SO_2 applied[81]. Actually, in this study, only about 1% of the applied SO_2 was detected leaving the lehr. The other 49% was unaccounted for. Cardinal used data from source tests from the Guardian float glass plant in DeWitt, IA to estimate uncontrolled losses at about 12% of SO_2 applied[82]. Because the later estimate is based on actual source testing and reasonable engineering calculations, Ecology gives it greater merit than the Kentucky estimate.

As part of the BACT determination, Cardinal proposes limiting the application of SO_2 in the lehr to not more than 0.25 lb SO_2/T_G. On the basis of the Guardian-DeWitt estimate, uncontrolled SO_2 emissions from the lehr would be about 0.03 lb SO_2/T_G (3.6 TPY). Given the proximity of the hood located between the tin bath and lehr to the SO_2 application point, it is reasonable to believe that a high proportion of the SO_2 that fails to adsorb to the glass will be captured into the hood. As noted in §2.3.3, Cardinal proposed that SO_2-laden air captured into the hood be routed through the spray dryer/ESP system used for glass furnace emissions. Ecology believes a 50% capture rate of the SO_2 from the lehr would be a conservative estimate. This would leave about 1.8 TPY SO_2 as fugitive emissions.

In order to capture these fugitive SO_2 emissions, the entire lehr would have to be hooded and vented with forced air to a control device. The lehr section represents about 10% of the plant floor space. Based on the minimum estimate of vent requirements to cover the whole plant (discussed in greater detail in §2.6), Ecology estimates a hypothetical lehr hood system would have to draw at least 8,000 cubic feet per minute (cfm) of room air to capture the fugitive SO_2 emissions. The SO_2 concentration in this vent stream would then be about 5 parts per million by volume (ppmv). Ecology knows of no commercially applied technology designed to remove SO_2 from such a low concentration, and knows of no float glass plants having treatment systems to independently control fugitive SO_2 emissions from the lehr. Ecology concludes that it is technically infeasible to capture and treat the fugitive SO_2 emissions from the lehr. Ecology concludes that **BACT for SO_2 emissions from the lehr is a limit on SO_2 applied in the lehr of 0.25 lb SO_2/T_G, and continuous operation of the hood located between the tin bath and lehr during glass production with routing of the vent from the hood to the spray dryer/ESP system**

[79] IPPC, op. cit, page 188
[80] Op. cit., page 11.15.4
[81] "Final Determination on the Application of AFG Industries, Incorporated to Construct and Operate a Flat Glass Manufacturing Plant to be Located in Richmond, Kentucky," Kentucky Department of Environmental Conservation (8/28/97)

[82] Correspondence between S. Klafka - Wingra Engineering, S.C. and F. Langenbach - North Carolina Department of Environment and Natural Resources, Amendment to BACT Analysis for Annealing Lehr, July 17, 1998.

used for glass furnace emissions. Emission limits for SO_2 from the spray dryer/ESP system have already been established in §2.3.3.

2.5 MATERIAL HANDLING BAGHOUSES

The general raw material handling operation in a float glass manufacturing facility creates a relatively small amount of particulate emissions. Ecology knows of no factors for uncontrolled emissions. EPA's AP-42 refers to the uncontrolled emissions as "negligible[83]." Neither the EPA's or California's permit data bases nor the IPPC report[84] provide insights.

Cardinal proposed that emissions from the cullet return and glass sheet cutting/packing systems (routed to a central exhaust system) and raw material handling systems be passed through baghouses. Cardinal proposed a limit on total particulate emissions from these sources of 2.1 lb/hr and 0.005 gr/dscft. EPA's permit data base[85] shows the following corresponding permit terms, all with baghouse control:

Table 6: Material Handling Particulate Emissions Limits for U.S. Float Glass Manufacturers

Source	Year permitted	Particulate Emission Limit
		gr/dscft
Cardinal-Durant	2003	0.005
Cardinal-Portage	1999	0.02
Cardinal-Mooresville	1998	0.0068
Cardinal-Portage	1994	0.02
U.S Glass-Donoro	1990	0.02

Since Cardinal's proposed emission limit appears to meet or exceed the lowest limit for a float glass plant, **Ecology concludes that 0.005 gr/dscft (24-hr average) is BACT for the material handling operations at the proposed Cardinal-Winlock facility**.

2.6 GLASS CUTTING

After passing through the cooling and annealing process in the lehr section, the glass is cut into sheets. This requires application of a cutting lubricant between the cutting blade and the glass surface. The lubricant is mineral spirits (Stoddard solvent). As an air pollutant subject to PSD consideration, mineral spirits is a VOC. Mineral spirits is actually a family of solvent/lubricant products loosely called petroleum distillates. Depending on the supplier and product specification, mineral spirits are liquid mixtures of at least 200 different hydrocarbons, primarily consisting of C_7 to C_{12}-alkanes and cycloalkanes (nominally in a 60:40 ratio), with up to 20% aromatic hydrocarbon content, of which less than 0.1 % is benzene. Cardinal's mineral spirits supplier stated that the product to be used at Cardinal-Winlock is less than 5% aromatics[86]. The typical

[83] Op. cit., Table 11.15.1
[84] U.S. EPA RACT/BACT/LAER Clearinghouse; California Best Available Control Database; IPPC, op. cit.
[85] U.S. EPA RACT/BACT/LAER Clearinghouse, op. cit.
[86] Electronic communication: " Regulated Constituents in Odorless Mineral Spirits," Bob Hinrichs (Citgo Petroleum Co.) to Steven Klafka (Wingra Engineering S.C.) forwarded to Bernard Brady (March 9, 2004)

initial boiling point is about 300-320 ^{o}F. The typical flash point (temperature at which it will ignite if exposed to a flame) is 100-120 ^{o}F. In addition to its use as an industrial glass cutting lubricant, mineral spirits are widely used in dry-cleaning fluids, paint thinners, varnishes, photocopy toners, inks, adhesives, and as general purpose cleaners and degreasers[87].

The mineral spirits applied to the glass will gradually evaporate to the air inside the manufacturing facility as the glass sheets pass across the snap rollers, stacking, packing, warehousing, and various handling stages. Without further consideration, the air borne mineral spirits will exit the facility through windows, doors, and various local air circulation vents as fugitive emissions. In order to destroy the mineral spirits vapors before they escape to the outside atmosphere, it would be necessary to collect all escaping air from the facility. No float glass making facility has been required to do this. The following discussion is intended to illustrate why this is a technically infeasible.

The available systematic information about industrial ventilation is very scarce. Approved target levels for industrial ventilation do not exist."[88] Industrial ventilation rates are designed with consideration of the toxicity and employee productivity impact of the chemicals released in the manufacturing process. Ventilation rates may vary from as low as three times an hour to as much as once every two minutes. About five times per hour is "a respectable rate by today's standards."[89] Cardinal's proposed Winlock facility should have about 350,000 square feet under one roof[90]. Ecology estimates an average ceiling height of 30 feet. At five turnovers per hour, Cardinal-Winlock would have to collect and vent 875,000 cfm. Cardinal proposes limiting the use of glass cutting lubricant to 44 TPY. Assuming a 100% capture, the concentration of mineral spirits vapor in the building vent would be less than 1 ppmv. For the sake of comparison, ventilation requirements based on the heuristics in Industrial Ventilation[91] suggest Cardinal-Winlock would have to collect and vent 72,500 cfm. On that basis, the VOC concentration would be about 6 ppmv. Ecology knows of no control technology designed to remove VOCs at such low initial concentrations except for extremely toxic chemicals where cost is essentially no object. Mineral spirits is a low-toxicity chemical blend. Consequently, Ecology concludes that capturing the mineral spirits vapor from the glass cutting lubrication is technically infeasible. **Ecology concludes that BACT for Cardinal Winlock's proposed use of glass cutting lubricant is the use of mineral spirits at not greater than 7,317 lbs/month.**

3.0 AMBIENT AIR QUALITY ANALYSIS

3.1 REGULATED POLLUTANTS

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[87] "Ontario Air Standards fir Mineral Spirits," Ontario Ministry for the Environment (March, 2001); Shell Oil Company Material Safety Data Sheets for ShellSol 9, 15, and 16.

[88] Special issue on Industrial Ventilation, EUROVENT – CECOMAF Review, March 2001 No 29

[89] " Hanford--PFP Ventilation Systems Trip Report (May 24-26, 1994)," memorandum for G. W. Cunningham, Technical Director from Roger Zavadoski, Defense Nuclear Facilities Safety Board (June 30, 1994)

[90] Cardinal FG brochure provided with PSD application for this project.

[91] Industrial Ventilation, A <annual of Recommended Practice - 24th edition, American Conference of Governmental Industrial Hygienists (2001). Calculation basis: Recommended ventilation rate for Stoddard Solvent from a dispersed evaporation space.

PSD rules require an assessment of ambient air quality impacts from any facility emitting pollutants in significant quantities. Limiting increases in ambient pollutant concentrations to not exceed the maximum allowable increments prevents significant deterioration of air quality.

3.1.1 Modeling Methodology

Cardinal submitted the modeling protocol to Ecology and the federal land managers (FLMs) on March 7, 2003[92]. The modeling protocol describes the relevant source parameters, anticipated Class II radius of impact, dispersion modeling methodology, potentially impacted federal wilderness areas (see Table 8), and source of meteorological data. Neither Ecology nor the FLMs expressed objection to the proposed protocol, and the permit application was prepared on the basis of that protocol with the exception of two amendments:

- Ecology requested that Cardinal use the AERMOD-PRIME dispersion model rather than the ISC3 model[93], and
- Ecology requested that Cardinal develop and use an alternative to *the 20D Method* for developing a regional source inventory. Cardinal developed and used a special case methodology referenced as the *Lewis County Screening Method* in the PSD application[94].

The majority of the terrain elevations in the Class II area modeling domain are below the top of the shortest stack. The site elevation is approximately 136 meters (446 feet). Directly north and south of the site, elevations remain below 150 meters (492 feet) within 10 km. Elevations rise to 175 meters (574 feet) just east of Mary's Corner approximately 10 km east of the site. The greatest increase in elevations occurs approximately 5 km west of the site. At that point the elevation is 250 meters (820 feet) with a peak of 454 meters (1490 feet) at Sam Henry Mountain. Since terrain elevations exceed 50% of the shortest stack height, receptor elevations were included in the modeling analysis. Elevations were imported from 7.5 minute digital elevation model (DEM) files for the surrounding area based on the 1927 datum, NAD27. For consistency, DEM files were used to establish elevations for both the receptor grids and project site. Dispersion modeling software automatically interpolated receptor elevations from the DEM data.

On-site weather data that was monitored for the year 1994 for the PSD permit for a gas turbine project in nearby Chehalis, Washington was combined with additional weather monitoring conducted at the Ed Carlson Memorial Field, South Lewis County Airport (formerly the Toledo-Winlock Airfield). The on-site meteorological data were processed using AERMET. The data were supplemented with Seattle surface data and upper air data from Quillayute. Land use in the surrounding area is rural.

A fence will not be used to impede public access to the facility. Therefore, receptors were placed within the facility boundaries. A coarse grid with receptor spacing of 500 meters

[92] "Application Plan and Modeling Protocol for Cardinal GF Glass Plant Project Napavine, Washington," ," prepared by Wingra Engineering SC, Madison, WI
[93] The Industrial Source Complex Short Term, Version 99020 model with – Plume Rise Model Enhancements
[94] Cardinal-Winlock PSD application, op. cit., page 65

was first used to determine the location of maximum impacts. A fine grid with receptor spacing of 100 meters was then used to verify the maximum concentrations. The receptor grids are shown in Appendix F of the PSD permit application. Modeling results were reviewed to assure decreasing concentrations at the outside boundary of the receptor grid. Final concentrations demonstrating compliance with air quality standards were determined using a denser receptor spacing of 100 meters to assure the maximum concentrations were predicted.

A GEP stack height and building wake effect analysis was performed using the EPA approved Building Profile Input Program (BPIP). The program was used to develop the appropriate 36 direction-specific building dimensions for the AERMOD model for each point source modeled. The BPIP results were incorporated into the dispersion model prior to conducting the air quality impact analysis. The BPIP model determines GEP for all facility structures. All facility stacks were less than GEP stack height and influenced by structural wake effects. The PRIME model was used to more accurately estimate downwash effects. The PRIME algorithms have been integrated into the AERMOD model. PRIME addresses the entire structure of the wake, from the cavity immediately downwind of the building to the far wake.

3.1.2 Modeling Results

Table 7 shows the highest concentration in Class I and II areas for each criteria pollutant that is expected to have emissions in excess of PSD significance and having a NAAQS (NO_x[95], CO, SO2, and PM_{10}[96]; See Table 1). Neither CO nor ozone (VOCs) has PSD increment consumption limits.[97]

The screening modeling results for CO (one-hour and eight hour averages) and PM_{10} (24-hour and annual averages) indicate that the maximum concentrations expected from this project are below "modeling significance" for both Class I and Class II areas. NO_2 is below modeling significance only for Class I areas. This means the modeled impact of the project is insufficient to justify or require further modeling analysis to determine the precise impact of CO, SO_2, and PM_{10} emissions on the area's attainment of the National Ambient Air Quality Standards (NAAQS). The maximum modeled concentration for all pollutants at all NAAQS averaging periods are also insufficient to justify or require impact monitoring, and are within the allowable increment[98] consumption level.

The screening modeling results show maximum pollutant concentrations for NO_2 (annual average) attributable to Cardinal exceed the modeling significance levels in the surrounding Class II area. As a result, under PSD analytical protocol, Cardinal was

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[95] For comparison with the NAAQS, 75% of the NO_x is assumed to be in the form of NO_2, as allowed by the 40 CFR Part 51, Appendix W guidelines.

[96] Proposed new or modified sources are not required to perform an ambient impact analysis for ozone (VOCs) unless the net emissions increase of VOCs is 100 TPY or more. USEPA New Source Review Workshop Manual, Table C-3 (October, 1990)

[97] ibid., Table C-2

[98] A PSD increment is the maximum allowable increase in concentration that is allowed to occur above a baseline concentration for a pollutant. The baseline concentration is that ambient concentration existing at the time that the first complete PSD permit application was submitted for a source that would affect the area [USEPA NSR Workshop Manual (1990), Chapter C, §II]. The 24-hour average PM_{10} baseline for this area was triggered on August 23, 1979.

required to perform a second level analysis that included all sources contributing to NO_2 concentrations within Cardinal's radius of influence[99] (ROI).

"All sources contributing to NO_2 concentrations within Cardinal's ROI" means sources whose impacts are significant within the Cardinal ROI. Cardinal included 1500 sources from Western Washington in an initial screening analysis. Only three sources were large enough and close enough to produce an impact greater than ten percent of the significant impact within the ROI (0.1 µg/m^3). This cumulative impact analysis indicated that potential NO_2 emissions from all existing sources plus Cardinal Winlock's proposed emissions do not exceed the NAAQS or allowable increment.

Table 7: Significant Impact Modeling Results Attributable to Cardinal-Winlock

Pollutant	Modeling Results, micrograms per cubic meter (µgrams/m^3)		Modeling Significance Level µgrams/m^3		Class I area Allowable Increment Consump-tion µgrams/m^3	Class II area Allowable Increment Consumption µgrams/m^3	Monitoring Requirement Threshold µgrams/m^3	NAAQS[100] µgrams/m^3
	Class I area	Class II area	Class I area[101]	Class II area				
NO_2, annual average	0.008 All NO_x as NO_2	2.6 All emission sources 33.6 Including back-ground	0.1	1.0	2.5	25	14	100
CO, 1 hour average	N/A	651	N/A	2,000	N/A	N/A	None	10,000
CO, 8 hour average	N/A	139	N/A	500	N/A	N/A	575	35,000
SO_2, 3 hour average	0.048	10.4	1.0	25	25	512	None	1,300
SO_2,	0.012	2.4	0.2	5	5	91	13	365

[99] The radius of influence is defined by the perimeter outside which Cardinal's pollutant emission impact is less than the modeling significance.
[100] These are both the primary and secondary NAAQS except for CO which has no secondary NAAQS.
[101] Proposed by EPA: Federal Register Volume 61 No. 142 page 38292 (7/23/96)

Pollutant	Modeling Results, micrograms per cubic meter (μgrams/m^3)		Modeling Significance Level μgrams/m^3		Class I area Allowable Increment Consump-tion μgrams/m^3	Class II area Allowable Increment Consumption μgrams/m^3	Monitoring Requirement Threshold μgrams/m^3	NAAQS[100] μgrams/m^3
	Class I area	Class II area	Class I area[101]	Class II area				
24 hour average								
SO_2, annual average	8×10^{-4}	0.3	0.1	1	2	20	None	80
PM_{10}, 24 hour average	0.036	3.8	0.3	5	10	37	10	50
PM_{10}, annual average	0.002	0.5	0.2	1	5	19	None	150

Ecology concludes that Cardinal's ambient impact analysis indicates that NO_x, CO, SO_2, and PM_{10} emissions from the proposed project are below ambient air quality standards established to protect human health and welfare for Class II areas and assure special air quality protection to Class I areas.

3.2 TOXIC AIR POLLUTANTS

PSD rules require the applicant to consider emissions of toxic air pollutants during the course of BACT analysis. One reason for this requirement is to ensure that the source does not employ an emission control technique that controls the main pollutant of concern, but emits a new toxic air pollutant in serious quantities. Ecology's regulations (Chapter 173-460 WAC) require an ambient air quality analysis of TAP emissions. All NSR requirements pursuant to WAC 173-400-110 are addressed in detail by SWCAA under notice of construction approval review. SWCAA's review also fulfills the PSD review requirement. Approval by SWCAA that T-BACT will be used by Cardinal-Winlock and that adequate modeling has been done by Cardinal to indicate acceptable impacts will constitute adequate consideration of TAPs impacts under this PSD permit.

4.0 AIR QUALITY RELATED VALUES

The PSD regulations require an evaluation of the effects of the anticipated emissions from the proposed source on visibility, soils, and vegetation in Class I and II areas, and the effect of increased air pollutant concentrations on flora and fauna in the Class I areas. Impacts were evaluated for the six Class I areas and one Class II wilderness areas within

150 km of Cardinal (Table 8). Cardinal modeled its emissions impact on the Class I areas and Class II wilderness areas using the CALPUFF[102] system.

Table 8: Potentially Impacted Wilderness and Scenic Areas

Class I Area	**Approximate Distance from Cardinal, kilometers**
Alpine lakes Wilderness	143
Goat Rocks Wilderness	81
Mt. Adams Wilderness	80
Mt. Hood Wilderness	121
Mt. Rainier National Park	74
Olympic National Park	141
Class II Area	**Approximate Distance from Cardinal, kilometers**
Columbia River Gorge NSA	116

4.1 IMPACTS ON VISIBILITY

All the wilderness and scenic areas listed above are more than 50 km from Cardinal. Consequently, the only required visibility analysis is an evaluation of haze impairment which changes the appearance of a viewed background feature.

Visibility impairment may interfere with the management, protection, preservation, or enjoyment of a visitor's visual experience of a Federal Class I Area. Federal rules dictate that this is judged on a case by case basis taking into account the geographic extent, intensity, duration, frequency, and time of visibility impairments, and how these factors correlate with times of visitor use of the Class I area, and the frequency and timing of natural conditions that reduce visibility[103]. According to guidance from the FLMs[104], a 5% increase in visible haze will evoke a just noticeable change in most landscapes. The FLMs are concerned about situations in Class I areas where an increase in visible haze, compared against natural conditions, caused by new source growth is greater than 5%. Haze increases that are attributable to a single source that are greater than 10% are generally considered unacceptable by the FLMs and will likely raise objections to further pollutant loading without mitigation. For visibility impacts on Class I areas between the 5% concern, and 10% not-acceptable levels, and after consideration of the federal rule,

[102] CALPUFF modeling system, Phase 2 Summary Report and Recommendations for Modeling Long Range Transport and Impacts, EPA-454/R-98-019, Interagency Workgroup on Air Quality Modeling, USEPA Office of Air Quality Planning and Standards, Research Triangle Park, NC27711 (1998)
[103] 40 CFR 51.301(a)
[104] "Federal Land Managers Air Quality Related Values Workgroup (Flag), Phase I Report," page 26 (December 2000)

the FLMs recommend a cumulative impact analysis to assure that the sum of the visibility impacts from all new sources is below 10%. For Class II wilderness and scenic areas, the FLMs acknowledge that the application of BACT to the proposed project is the mitigation remedy allowed in the regulations[105].

According to Cardinal, all float glass furnaces experience deposition of sulfate salts in the refractory checkers whether using the 3R process or otherwise. The sulfate deposits are periodically burned out. This was discussed in §2.3.1.8. The additional NO_X emissions from a maximum of two potential annual burnouts were included in the annual average air-NO_2 concentration impacts given in Table 7. However, visibility impacts are considered on a daily (24-hour average) basis, and will be different depending on whether or not the 3R Process is on-line. Consequently, Cardinal modeled visibility impacts for both normal (3R Process on-line) and burnout operation.

The modeling results under non-burnout maintenance operation[106] indicate that the visibility impact of Cardinal's pollutant emissions will exceed the FLMs concern threshold only in Olympic National Park, one day in every three years. That day will most likely be in December. In consideration that December has generally poor visibility conditions and a history of low visitorship in scenic view areas, the FLMs did not find this to be an adverse impact. Table 9 shows the modeling results.

[105] ibid., Appendix C

[106] "Response to November 24th Request for Information, Air Quality Permit Application, Cardinal FG Company Glass Plant Project Lewis County, Washington," Steven Klafka (Wingra Engineering S.C.) to Bernard Brady (January8, 2004)

Table 9: Wilderness and Scenic Area Visibility Impacts, non-maintenance operation

Class I Area	Days in three years having over 5% visibility impairment	Maximum Visibility impairment	Time of year
Alpine lakes Wilderness	None	<3%	May
Goat Rocks Wilderness	None	4.8%	July
Mt. Adams Wilderness	None	<3%	July
Mt. Hood Wilderness	None	<3%	July
Mt. Rainier National Park	None	4.6%	July
Olympic National Park	One	7.7%	December
Class II Area	**Days in three years having over 5% visibility impairment**	**Visibility impairment if over 5%**	**Time of year**
Columbia River Gorge NSA	None	<3%	April

Visibility impact modeling for burnout-maintenance operation indicated that if Cardinal were to be allowed to perform this maintenance activity at any time, visibility degradation above the FLM concern threshold would occur with an unacceptable frequency at certain times of the year: An average of about six times per year in each of the periods April through July and October through December. However, during the remaining periods of the year, only one or two days of greater than 5% visibility degradation would occur each year on the average. This is most likely to occur sometime in January through March or in late September. The level of visibility degradation should reach about 5% to 6%, and may occur in either Mt. Rainier National Park or Olympic National Park (but not at the same time). Cardinal proposed that the burnout maintenance be limited to these low-impact periods[107]. In consideration that the January through March period has generally poor visibility conditions and a history of low visitorship in scenic view areas, and that modeling predicted few concern-level visibility impacts for August and September, the FLMs did not find this to be an adverse impact.

Ecology differs with the FLMs apparent position slightly. Visibility impact modeling is not an exact science. Although predicted by Cardinal's modeling exercise, Ecology believes it is unlikely that concern-level visibility impacts will stop dramatically on July 31st. Furthermore, August is the month of greatest visitor-frequency to the scenic areas (over ten times the winter visitor-frequency). Ecology believes it would be too risky and inappropriate to allow burnout maintenance during August. **Ecology concludes that burnout-maintenance will be restricted to not more than twice in any twelve month period, and to the months of January, February, March, and September**.

[107] ibid.

4.2 OTHER AIR QUALITY RELATED ISSUES

4.2.1 Class I Area Air Pollutant Impact

Air concentrations of NO_x and fallout from its derivatives have the potential to impact flora and fauna in the area surrounding an emissions source. Cardinal modeled the maximum increase in NO_x concentrations for each Class I area caused by the proposed project. As shown in Table 7, above, the maximum increase in Class I area NO_x concentrations is about 13% of the Class I area significant impact level of 0.03 μgrams/m^3.

4.2.2 Class II Area Impacts on Soils, Vegetation, and Animals

According to the EPA's NSR guidance[108], for most types of soils and vegetation, ambient concentrations of criteria pollutants below the secondary national ambient air quality standards will not result in harmful effects. As shown in Table 7, maximum ambient NO_x pollutant concentrations attributable to the proposed project are below the secondary national ambient air quality standard. Exceptions exist where particular species are sensitive to particular pollutants. No such sensitive species have been identified.

Cardinal performed an impact analysis following EPA guidance[109]. Cardinal-Winlock emissions of SO_2 or NO_X do not exceed 3% of the screening threshold criteria. Coupled with existing background concentrations, the impact after Cardinal-Winlock begins operation will be less than 35% of the screening criteria. VOC emissions are insufficiently high to be required to be included in the impact analysis.

Under the Federal Code of Regulations 50.402 and 50.600, the EPA is required to consult with the US Department of Fish and Wildlife (USDFW) and National Marine Fisheries Service (NMFS) to determine whether the proposed new source "is likely to jeopardize the continued existence of [endangered] species or result in the destruction or adverse modification of the [related] habitat[110] [or] adversely affect endangered fisheries habitat[111]." This consultation takes place separately from NSR and PSD permitting. However, the PSD permit cannot be final and effective until the EPA either determines that the proposed new source is not likely to have adverse impacts on endangered species or fisheries or issues a biological opinion specifying required mitigations[112]. This process is currently underway.

The State Environmental Policy Act (Chapter 43.21C RCW) and derivative Washington rules (173-802 WAC, 173-806 WAC, and 197-11 WAC) require that aggregate and cross-environmental agency environmental impacts be evaluated under the coordination of a "lead agency." For the proposed Cardinal project, the lead agency for the State Environmental Policy Act (SEPA) review is Lewis County. In that role, under state and local law, the Lewis County Commissioners must review and approve the project before

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[108] *op. cit.*, Chapter D, § IIC
[109] United States Environmental Protection Agency. *A Screening Procedure for the Impacts of Air Pollution Sources on Plants, Soils, and Animals*. Office of Air Quality Planning and Standards, EPA 450/2-81-078. December 12, 1980.
[110] 40 CFR Part 402.10(a)
[111] 40 CFR 600.920(a)
[112] 40 CFR 400.14(k)

the issuance of any permits[113]. To assist the Lewis County Commissioners in making their decision, Cardinal prepared a Final Environmental Impact Statement (FEIS)[114]. The FEIS discusses a wide variety of potentially affected environmental categories: Earth, air, water, plants and animals, energy and natural resources, environmental health, land use, transportation, socioeconomics, public services, visual aesthetics, noise, and cultural resources. Consistent with the focus of this section, the following is a brief summary of the relevant sections of the FEIS:

Water Resources: Alternate plans are still being evaluated subject to available water rights, cost, and Washington State and Lewis County regulations.

Wastewater: Process wastewater will be treated on-site and re-used by Cardinal. Stormwater runoff control will be in accordance with design principals in "Stormwater Management Manual for Western Washington[115]."

Plants and Animals: The area is designated under the National Wetlands Inventory as Palustrine Seasonally Flooded, Forested Wetland. No endangered or proposed-as endangered species are known to be within one mile of the proposed facility according to available information and reports from the US and Washington Fish and Wildlife Services.

Available nearby wildlife habitat is sufficiently adequate such that disruption attributable to locating the proposed facility is negligible.

Ecology believes that the evaluation processes required under the EPA consultations with USDFW and NMFS and Lewis County's evaluation of Cardinal's FEIS assure protection of soils, vegetation and animals from the potential impacts of Cardinal's air pollutant emissions. **Ecology concludes that the proposed Cardinal-Winlock facility will have no significant impact on Class II area soils, vegetation, and animals.**

4.2.3 Class I Area Deposition

Similar to the FLAG guidance on the concern threshold for visibility impact in Class I areas, the National Park Service has suggested 0.005 kilograms per hectare per year (kg/ha-yr) as the concern threshold for increases in nitrogen or sulfur deposition[116] due to a proposed project for Class I areas. Table 10 shows that the highest modeled annual surface deposition rates of nitrogen and sulfur in the potentially impacted Class I areas would not exceed the concern threshold. Note that the modeled deposition rates are based on Cardinal-Winlock's first year of NO_X emissions, and represent a worst-case scenario (see §2.3.1.8).

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[113] Fact Sheet, Lewis County Major Industrial Development, Applicant: Cardinal FG Company (July 14, 2004)
[114] Cardinal FG Company, Float Glass Manufacturing Plant, Winlock, Washington; Final Environmental Impact Statement; prepared by Pacific International Engineering (July 2004)
[115] Washington Department of Ecology Publication 99-11 through 99-15
[116] "Guidance on Nitrogen Deposition Analysis Thresholds," National Park Service (August, 2001)

Table 10: Dry and Wet Nitrogen Deposition

Class I Area	Maximum Nitrogen Deposition (3 year average) kg/ha-yr	Maximum Sulfur Deposition (3 year average) kg/ha-yr
Alpine lakes Wilderness	0.0048	0.0012
Goat Rocks Wilderness	0.0032	0.0007
Mt. Adams Wilderness	0.0023	0.0005
Mt. Hood Wilderness	0.0011	0.0003
Mt. Rainier National Park	0.005	0.0012
Olympic National Park	0.0026	0.0007
Class II Area	**Maximum Nitrogen Deposition kg/ha-yr**	**Maximum Sulfur Deposition (3 year average) kg/ha-yr**
Columbia River Gorge NSA	0.0028	0.0007

4.3 CONSTRUCTION AND GROWTH IMPACTS

The PSD regulations require that a growth impact analysis be conducted for the project. Procedures for this analysis are described in the USEPA New Source Workshop Manual[117]. The glass plant will operate 24 hours per day and 7 days per week. Traffic associated with plant operations includes employee vehicles and semi-trailer trucks.

Traffic from the proposed facility will exit onto County Highway 603 and then travel on U.S. Highway 12 and Interstate 5. In 2002, Lewis County Public Works Department measured traffic on County Highway 603 at 2,514 vehicles per day. In 2001, the Washington Department of Transportation measured traffic on U.S. Highway 12 at 7,000 vehicles per day, and on Interstate 5 at 43,000 vehicles per day. These measurements reflect traffic traveling in both directions.

The estimated traffic entering and leaving the proposed glass plant is 300 vehicles per day. This suggests that traffic on County Highway 603 will increase 12%. Traffic on U.S. Highway 12 will increase 4%, and traffic on Interstate 5 will increase 0.7%. The proposed facility is not expected to result in significant growth in local vehicle traffic.

Ecology concludes that the proposed modifications will not cause excessive construction or growth related air quality impacts at or around the Cardinal.

5.0 CONCLUSION

The project will have no significant adverse impact on air quality or air quality related values. The Washington State Department of Ecology finds that the applicant, Cardinal

[117] Op. cit.

FG, has satisfied all requirements for approval of a PSD permit for the proposed Cardinal-Winlock project.

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